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VOC (VOLATILE ORGANIC COMPOUND) FUGITIVE EMISSION PREDICTIVE MODEL - USER'S GUIDE

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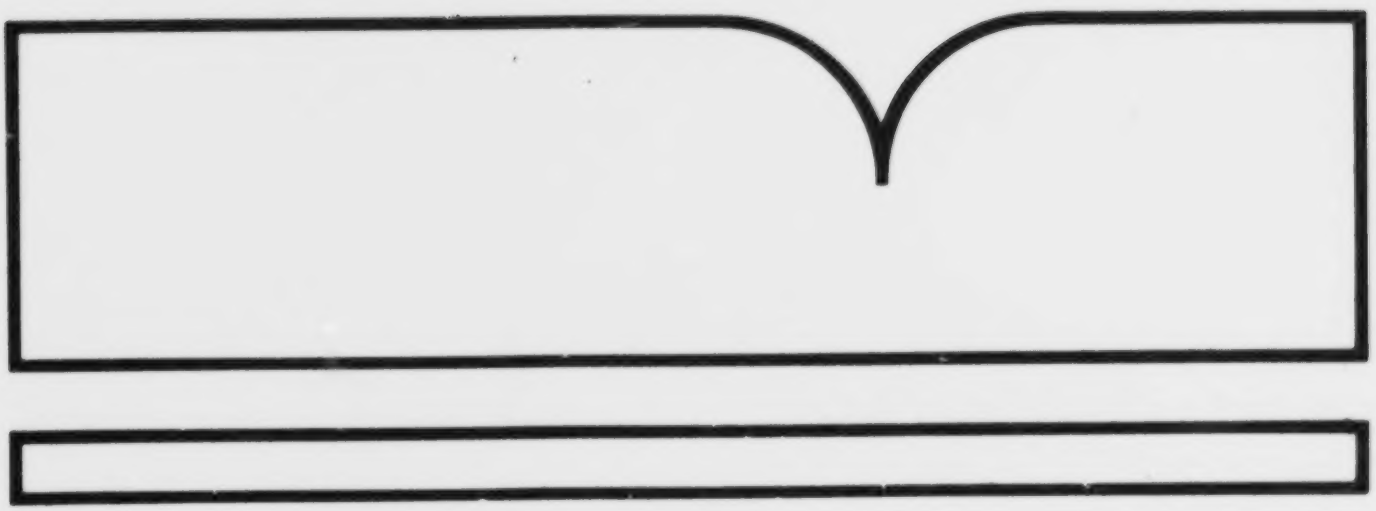

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VOC FUGITIVE EMISSION PREDICTIVE MODEL - USER'S GUIDE

by

J. I. Steinmetz and L. P. Provost
Radian Corporation
8501 Mo-Pac Blvd.
P.O. Box 9948
Austin, TX 78766

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EPA Project Officer:
Bruce A. Tichenor
Industrial Processes Branch
Industrial Environmental Research Laboratory
Research Triangle Park, NC 27711

OFFICE OF RESEARCH AND DEVELOPMENT
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16. ABSTRACT The report discusses a mathematical model that can be used to evaluate the effectiveness of various leak detection and repair (LDAR) programs on controlling volatile organic compound (VOC) fugitive emissions from chemical, petroleum, and other process units. The overall effectiveness of a LDAR program can be examined by studying leak occurrence frequency, leak emission rates, leak recurrence frequency, repair effectiveness, and process unit shutdown frequency. Additionally, examining the time required for simple on-line maintenance and inspection, repair parts and labor costs, and administrative and support overhead costs can be used to quantify the expected costs and cost-effectiveness of alternative LDAR programs. The model is capable of evaluating leak detection/maintenance frequencies of 1, 3, 6, 9, and 12 months. Another feature of the model incorporates the uncertainty of the inputs for examining emission reductions to calculate approximate confidence intervals for the emission and reduction outputs. The report also describes a computer program, available through EPA's National Computer Center, that allows a user to enter LDAR input data and initiate the above-described model through a low-speed terminal.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Pollution Control	13B
Computer Programs	Stationary Sources	09B
Organic Compounds	Volatile Organic Compounds (VOC)	07C
Processing	Fugitive Emissions	13H
Leakage		14G
Maintenance		15E
Inspection		

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PREFACE

Leak detection and repair (LDAR) programs for fugitive emission sources are currently being developed for use in several processing industries. Data to evaluate the occurrence and recurrence of leaks from various process units and the effectiveness of simple on-line maintenance have been collected during the past several years. This report describes a mathematical model for evaluating the effects of various LDAR programs on controlling VOC fugitive emissions. The original version of the model is fully described in a Radian Corporation technical note (Reference 1). The current version has been developed under contract to the Industrial Environmental Research Laboratory, Research Triangle Park, NC, of the United States Environmental Protection Agency. In the current version, a cost-effectiveness analysis was added, along with several modifications intended to enhance the overall capabilities of the model. These modifications do not change the basic model's rationale or methodology.

This report explains a Statistical Analysis System (SAS) computer program which allows a user to enter LDAR input data and initiate the model discussed above through a low-speed terminal. The program is operational on EPA's National Computer Center (NCC) IBM computer. Access to the NCC-IBM is available to EPA, as well as other governmental units through EPA sponsorship. EPA contractors can use the system under EPA authorization. EPA ADP coordinators are located at various EPA organizational units, including Regional Offices, to assist potential users in gaining access to the NCC-IBM system.

ABSTRACT

The United States EPA Office of Air Quality Planning and Standards (OAQPS) has the responsibility for developing regulatory strategies to control fugitive emissions of volatile organic compounds (VOC). The report presented here was undertaken by EPA's Office of Research and Development to assist OAQPS in this effort.

This report presents a brief discussion of a mathematical model which can be used for evaluating the effectiveness of various leak detection and repair (LDAR) programs on controlling VOC fugitive emissions from chemical, petroleum, and other process units. The overall effectiveness of a LDAR program can be examined by studying leak occurrence frequency, leak emission rates, leak recurrence frequency, repair effectiveness, and process unit shutdown frequency. Additionally, examination of the time required for simple on-line maintenance and inspection, repair parts and labor costs, and administrative and support overhead costs can be used to quantify the expected costs and cost-effectiveness of alternative LDAR programs. A useful option in the model allows the determination of emissions reduction associated with alternative LDAR programs. The model is capable of evaluating leak detection/maintenance frequencies of one month, three months, six months, nine months and one year. Another feature of the model incorporates the uncertainty of the inputs for examining emission reductions to calculate approximate confidence intervals for the emission and reduction outputs.

This report also documents a computer program, available through EPA's National Computer Center, which allows a user to enter LDAR input data and initiate the above-described model through a low-speed terminal. Several application examples are presented to illustrate the various program outputs.

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SECTION 1

INTRODUCTION

Fugitive volatile organic compound (VOC) emissions from leaking process unit components comprise a significant source of the total VOC emissions from chemical and petroleum processes. Data to evaluate the occurrence and recurrence of leaks from various process units and the effectiveness of simple on-line repair have been collected over the past several years. This information has been used by the U.S. Environmental Protection Agency Office of Air Quality Planning and Standards (OAQPS) in the development of regulatory strategies to control VOC fugitive emissions. This study was undertaken by EPA's Office of Research and Development to assist OAQPS in this effort. This work effort was intended to develop a model for predicting the influence of leak detection and repair (LDAR) programs on the frequency of leaks and magnitude of mass emissions from chemical, petroleum, and other processing units. Additionally, the model was to be programmed for computer implementation.

This report contains four major sections and three appendices. A brief description of the LDAR model is presented in Section 2. A guide to using the interactive LDAR model software is presented in Section 3. Section 4 presents two example sessions using the LDAR model program. Enhancements made to the original LDAR model are described in Appendix A. Appendix B gives source program listings of the Statistical Analysis System (SAS) LDAR model program and various programs used in setting up the input data files and executing the LDAR program. Appendix C contains example input and output listings for the LDAR program.

SECTION 2

LDAR MODEL DESCRIPTION

The LDAR model is a mathematical model which can be used to evaluate the impact of various leak detection and repair programs on the frequency of leaks, monitoring and repair costs, and the magnitude of mass emissions from various equipment within processing units. The original version of the model is fully described in a technical note (Reference 1). In the current version, a cost-effectiveness analysis was added, along with various modifications intended to enhance the overall capabilities of the model. Modifications were made to the original LDAR model (described in Appendix A) to enhance the model's capabilities and provide for remote terminal operation. The modifications do not change the model's basic mathematical structure.

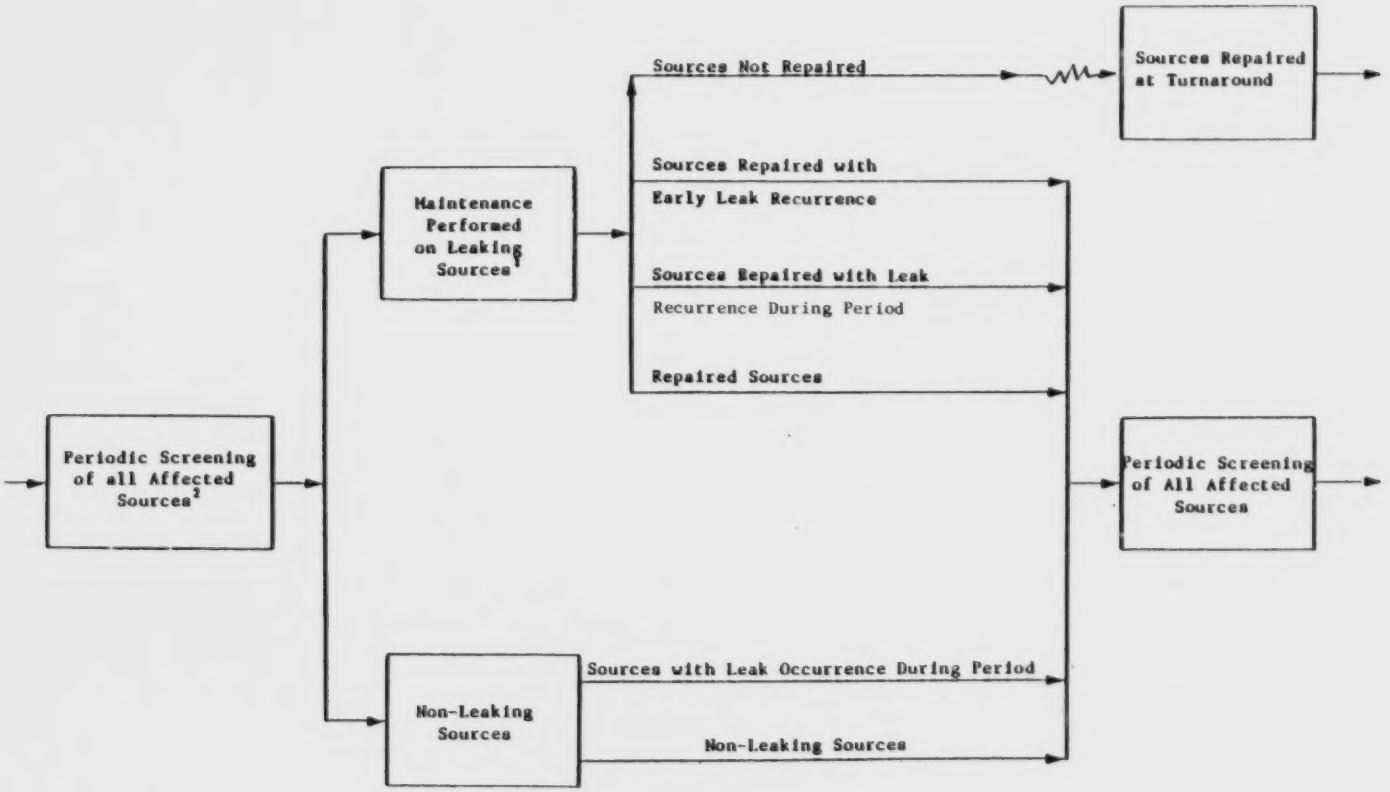
Briefly, the standard for specific process fugitive emission sources, such as valves, might require a work practice which includes periodic inspection of all affected sources, attempted repair of leaking sources, reinspection of repaired sources monthly until they are determined not to be leaking for two successive months, and repair of leaking sources (including those that could not be repaired on-line) during a process turnaround. The model incorporates these basic rules while allowing variable inputs for repair effectiveness, process unit shutdown frequency, leak occurrence frequency, repair time, labor rate, etc. The uncertainty of the inputs for examining emission reductions due to LDAR can also be incorporated into the model and approximate confidence intervals calculated for the emission and reduction outputs.

The model also includes options to evaluate alternative inspection and repair programs. The alternative programs are limited to leak detection

and repair at regular periods (one month, three months, six months, nine months, or one year) with optional monthly follow-up on repaired sources within a period.

Figure 1 shows a schematic diagram of the model for a simple leak detection and repair program with no monthly follow-up of repaired sources. Figure 2 shows a similar diagram for a modeled leak detection and repair program requiring quarterly inspection of all affected sources with re-inspection of repaired sources monthly until they are determined not to be leaking for two successive months.

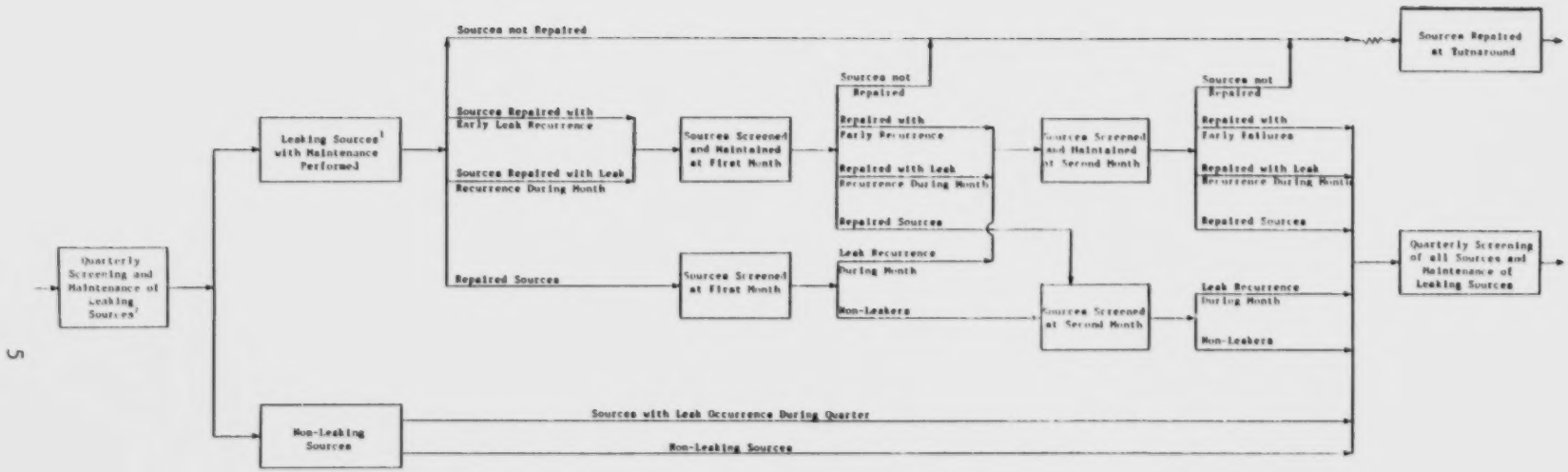
A more complete description of the LDAR model can be found in a technical note prepared by Radian Corporation (Reference 1).



[1]Leaking sources include all sources which had leak recurrence, had experienced early failures, or had leak occurrence and remained leakers at the end of the preceding period.

[2]Except sources for which attempted maintenance was not successful.

Figure 1. Schematic Diagram of a General Leak Detection and Repair Program.


Quarterly Screening and Maintenance of Leaking Sources[2]
Leaking Sources[1] with Maintenance Performed
Non-Leaking Sources
Sources not Repaired
Sources Repaired with Early Leak Recurrence
Sources Repaired with Leak Recurrence During Month
Repaired Sources
Sources Screened and Maintained at First Month
Sources Screened at First Month
Sources not Repaired
Repaired with Early Recurrence
Repaired with Leak Recurrence During Month
Repaired Sources
Leak Recurrence During Month
Non-Leakers
Sources Screened and Maintained at Second Month
Sources Screened at Second Month
Sources not Repaired
Repaired with Early Failures
Repaired with Leak Recurrence During Month
Repaired Sources
Leak Recurrence During Month
Non-Leakers
Sources Repaired at Turnaround
Quarterly Screening of all Sources and Maintenance of Leaking Sources
Sources with Leak Occurrence During Quarter
Non-Leaking Sources

[1]Leaking sources include all sources which had leak recurrence, had experienced early failures, or had leak occurrence and remained leakers at the end of the preceding quarter.

[2]Except sources for which attempted maintenance was not successful.

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Figure 2. Schematic Diagram of a Leak Detection and Repair Program Requring Quarterly Inspection with Monthly Follow-ups.

SECTION 3

LDAR MODEL--USER'S INFORMATION

Introduction

This section discusses the procedures required to use the interactive LDAR model software through EPA's National Computer Center (NCC) IBM system (access to the system is described in the preface of the report). It is designed to provide information necessary to enable users to enter LDAR input data and run the model through a low-speed terminal. The next section provides a step-by-step explanation on how to operate the model.

The following subsections describe the input/output data files and discuss how to operate the model from a remote terminal.

Putting the Model "On Line"

The LDAR model runs on the EPA NCC-IBM's TSO (Time Sharing Option) system. After "connecting" the remote terminal to the IBM (via telephone and modem or direct line), the system will require the user to designate TSO or OBS (On-line Business System-WYLBUR). The user responds with "TSO," and the system requests a "LOGON." After the user inputs "LOGON," the system sequentially asks for USERID, PASSWORD, and ACCTUID. The user must respond with proper, authorized codes for each of these requests. Both USERID and PASSWORD are identifiers for specific users and take the form:

USERID = EPAiii (6 characters)
PASSWORD = EPA--- (6 characters)

These codes are obtained via EPA ADP Coordinators. ACCTUID is an activity identifier and for LDAR:

ACCTUID = VOCFENGRDRAD (12 characters)

After successful input of the above codes, the computer will respond with "READY." The LDAR model can now be executed. First, the user must provide an execute statement. For batch runs, the execute statement is:

```
EXEC 'CN.EPASDJ.VOCF.LDAR.DATA(LDARB)' 'DATA(CN.EPAiii.VOCF.data set name) DEST(RMTn) STATUS(jjj)'
```

For interactive runs, the execute statement is:

```
EXEC 'CN.EPASDJ.VOCF.LDAR.DATA(LDAR)' 'DATA(CN.EPAiii.VOCF.data set name) DEST(RMTn) STATUS(jjj)'
```

where "iii" are the last three characters of USERID, "n" is a one-, two-, or three-digit remote destination identification (see Reference 3) and "jjj" represents the status of the input data set (OLD or NEW). The operating system requires the "data set name" to be a string of 29 characters or less (which must be divided by periods into segments of eight characters or less). The "data set name" enables an individual user to have access to more than one input data set. For example, USERID EPAxxx could name his input data sets as follows:

CN.EPAxxx.VOCF.TEST1.DATA

CN.EPAxxx.VOCF.TEST2.DATA

If the input data set has been cataloged then the STATUS(OLD) keyword in the EXEC command is not required.

If confidence intervals on emission and reduction estimates are desired, the job should be submitted to batch by using the first EXEC statement. A job requiring confidence intervals can be run interactively with a

slight program modification (allocating more space to the work data set); however, excessive time will be spent by the user at the terminal waiting for the interactive job to finish running.

Hardcopy output will be routed to the remote destination designated in the EXEC statement. Hardcopy can be obtained at any printing terminal via TSO's QUEUE system using "DEST(RMT225)" in the execute statement. Information on how to use QUEUE is available from EPA's NCC or by typing in "QUEUE" after the system is "READY."

Upon loading the LDAR program, the terminal will respond with one of the following messages:

```
*** LEAK DETECTION AND REPAIR (LDAR) MODEL (IN SAS 79.6)
*** FOR RUNNING A BATCH JOB
```

or

```
*** LEAK DETECTION AND REPAIR (LDAR) MODEL (IN SAS 79.6)
*** FOR RUNNING AN INTERACTIVE JOB
```

The remainder of the session consists of a series of queries and prompts from the program that require responses from the user.

Input Data Files

The input data files are created or changed by the LDAR program and are not coded by the user. The user's terminal serves as the interactive read and write units. The user's replies to data requests are read and the LDAR program's queries and output are written.

During an interactive session with the LDAR program, input data are entered, changed or deleted through user replies to specific questions or data requests from the LDAR program. In most cases, only the first letter of nonnumeric replies is necessary. For example, a "Y" has the same effect as "YES." A user has the option of either running the LDAR model program interactively or submitting the job to batch.

The following LDAR input parameters are required by the LDAR model program:

Model Plant ID
Source Type (e.g., valve, pump seal, etc.)
Service Type (e.g., gas, light liquid, heavy liquid)
Monitoring Interval (months)
Turnaround Frequency (months)
Emission Factor (kg/hr/source)
Leak Occurrence Rate (% per period)
Initial % Leaking
Emissions Reduction for Unsuccessful Repair (%)
Emissions Reduction for Successful Repair (%)
Early Leak Recurrence (% of repairs)
Unsuccessful Repair Rate (%)
Unsuccessful Repair Rate at Turnaround (%)

If a cost-effectiveness analysis is desired then the following additional input parameters are required:

Total Number of Sources
Monitoring Time (minutes/source inspection)
Visual Monitoring Time (minutes/source)
Number of Visual Inspections Per Year
Repair Time (minutes/source)
Labor Rate ($/hr)
Parts Costs ($/source)
Administrative and Support Overhead Cost Factor (%)
Capital Recovery Factor (%)
Recovery Credit for Emission Reductions ($/megagram)

Finally, if confidence intervals on emission and reduction estimates are desired then the following input parameters are required:

Standard Error of Initial % Leaking
Standard Error of Emission Reduction Due to Unsuccessful Repair
Standard Error of Emission Reduction Due to Successful Repair
Standard Error of Unsuccessful Repair Rate
Standard Error of Early Leak Recurrence
Lower 95% Confidence Limit on Leak Occurrence Rate
Upper 95% Confidence Limit on Leak Occurrence Rate
Lower 95% Confidence Limit on Initial Emission Factor
Upper 95% Confidence Limit on Initial Emission Factor

Using or Changing "OLD" Data

If the status of the input data file is "OLD" then the user will be queried as follows:

DOES YOUR INPUT DATA FILE PRESENTLY CONTAIN CASES
WHICH YOU WISH TO SAVE?

If the user wishes to delete all cases on the input data file and rebuild his file then he should respond "NO." If the user responds "YES" the program will identify the first case on the data file as in this example

MODEL PLANT A - GAS VALVES

and query the user as follows:

IS THIS A CHANGE, A DELETION, OR IS IT OK?

If the user wishes to keep the case as is, he should respond "OK." If he does not want to include this case, then he should respond "DELETE." Otherwise, if a change to one or more of the input parameter values is required, then he should reply "CHANGE." Changes and deletions are made to the permanent input data file. If the user's response is "OK" or "DELETE" then subsequent cases on the input data file will be identified and the user will be queried as above.

If the user's response is "CHANGE," he will get the following prompt:

```
IF A CHANGE IS REQUIRED RESPOND WITH THE CORRECTED VALUE,
OTHERWISE PRESS RETURN.

MODEL PLANT ID          A
```

Each of the input parameter descriptions will be listed with their current values (for the above example, "A" is the current value of Model Plant ID). If the user wishes to change the value of a parameter, he must enter the new value following the parameter description. If a change is not desired, he should respond with a blank or null line (carriage return with no data). Model plant ID, source type and service type are each limited to a length of 20-characters. If the length of these variable inputs is greater than 20-characters, they will be truncated.

Entering "NEW" Data

If the status of the input data file is "NEW" or all cases in the data file were deleted (user responded "NO" to the initial query), then the user will be prompted as follows:

```
RESPOND TO EACH PARAMETER DESCRIPTION WITH THE INPUT VALUE.

MODEL PLANT ID
```

Each input parameter description will be listed as a prompt to the user. He must enter the parameter value following the description.

Monthly Follow-Ups

If a quarterly or less frequent monitoring/inspection interval is being used, the user will be queried as follows:

ARE MONTHLY FOLLOW-UPS TO BE PERFORMED BETWEEN THE
PERIODIC SCREENING AND MAINTENANCE OF SOURCES?

If the user wants the LDAR model to incorporate monthly follow-ups between the periodic monitoring of sources, he should respond "YES." Otherwise, the user should respond "NO."

Confidence Intervals

ARE CONFIDENCE INTERVALS ON EMISSION AND
REDUCTION ESTIMATES DESIRED?

If the user wants confidence interval estimates and responds "YES," he will be prompted and/or queried as follows (depending on whether the case being input is new or an old case is being changed):

New case:

RESPOND TO EACH PARAMETER DESCRIPTION WITH THE INPUT VALUE.

STD ERROR OF INITIAL % LEAKING

Each variability input parameter description will be listed as a prompt to the user. He must enter the desired parameter value following the description.

Old case:

IS THIS A CHANGE OR ARE THE CONFIDENCE INTERVAL INPUTS OK?

If the user wishes to keep the confidence interval inputs as is, he should respond "OK." Otherwise, if a change to one or more of the confidence interval input parameter values is required, then he should respond "CHANGE." This response will get the following prompt:

IF A CHANGE IS REQUIRED RESPOND WITH THE CORRECTED VALUE,
OTHERWISE PRESS RETURN.

STD ERROR OF INITIAL % LEAKING

Each of the variability input parameter descriptions will be listed with the current values. If the user wishes to change the value of a parameter, he must enter the desired value following the description. If a change is not desired, he should respond with a blank or null line (carriage return with no data).

Output Options

IS A COMPLETE TABLED OUTPUT LISTING DESIRED?

If a complete hardcopy output listing (as described in the next section) is required then the user should respond "YES." If, however, the following selected output is sufficient the user should respond "NO."

Selected Output ("NO" response):

- input data listing
- table summarizing the fraction of sources screened and operated on by turnaround
- table summarizing emission factors (kg/hr) and percent reduction in mass emissions by turnaround
- table of initial leak repair costs
- table summarizing monitoring and leak repair costs
- table summarizing cost effectiveness.

Once the user has been queried about each of the cases on the input data file, he will have the option of adding new cases:

DO YOU WANT TO ADD ANOTHER CASE?

If the user's response is "YES," he will be prompted as before with each input parameter description. Otherwise, a "NO" response will end the LDAR data input phase of the interactive session.

If the job is to be run interactively, there will be no further prompts and the following message will be given:

*** YOUR INTERACTIVE JOB IS NOW BEING PROCESSED

As soon as the interactive job has been processed (it may take several minutes for the job to run), the following message indicating a remote destination (remote 15 for this user) will be given:

*** OUTPUT SENT TO PRINTER (RMT15)

The interactive session is now terminated and the user is returned to the time sharing system.

If the job is to be submitted to batch, the user will be prompted for his user ID, account code and initiation priority as follows:

ENTER YOUR 6-CHARACTER USER ID

The user should enter his six-character User-ID. This User ID is in the format EPAiii, where the characters "iii" are chosen for uniqueness (these are often referred to as a user's "initials").

ENTER THE 12-CHARACTER ACCOUNT CODE AUTHORIZED FOR EPAiii

The user must enter the twelve-character account code authorized for his user-ID (use VOCFENGRDRAD).

ENTER THE INITIATION PRIORITY FOR WHICH YOU WISH TO BE BILLED

The user must specify the priority for which he wishes to be billed. Valid priorities are 1, 2, 3, 4 or 5 (Reference 3). When confidence interval estimates are desired, job turnaround will be slow due to the CPU time required by the LDAR model program.

As soon as the job has been submitted to batch, the following message indicating the job number and remote destination (Job 4089 and remote 15 for this user) will be given:

```
JOB EPASDJ(JOB04089) SUBMITTED
*** OUTPUT SENT TO PRINTER (RMT115)
```

The interactive session is now terminated and the user is returned to the time-sharing system.

Outputs for Programmed Model

The model is programmed to simulate implementation of a LDAR program for six years. The output of the computer program is formatted for a 132 column printer and includes the following tables:

1. Input Data

   All of the input data is printed out for each model plant, source and service type combination (see previous list of input data).

2. Fraction of Sources Screened and Operated On

The following information is printed out for each turnaround period:

(a) Fraction of sources screened,

(b) Fraction of sources operated on.

If a complete tabled output is requested, the fraction of sources screened and operated on will also be given for each month of the six-year period and for each year.

3. Estimated Emission Factors and Percent Reduction in Emissions

For each turnaround period the following information is printed out:

(a) Average emissions per source (kg/hr) for the period (with an approximate 90% confidence interval),

(b) Average percent reduction in emissions for the period relative to initial emissions (with an approximate 90% confidence interval),

(c) Average percent reduction in emissions for the period relative to emissions resulting when the LDAR program is not in effect (with an approximate 90% confidence interval). See Appendix A for more information on this emission reduction estimate.

If a complete tabled output is requested, the above information will also be given for each monitoring period.

4. Fractional Distribution of Sources

If a complete tabled output listing is requested, the following quantities are printed for the beginning (immediately

following periodic maintenance) and for the end (just before periodic maintenance is performed) of each period:

(a) Fraction of leaking sources due to leak occurrence (screening $\geq$ action level),

(b) Fraction of sources with attempted but unsuccessful repair,

(c) Fraction of sources repaired but experiencing early failure,

(d) Fraction of non-leaking sources (screening $<$ action level).

5. Initial Leak Repair Costs

For each source/service type within a model plant, the following information will be printed:

(a) Initial leak frequency,

(b) Number of sources,

(c) Number of initial leaks,

(d) Parts cost for initial leak repair,

(e) Labor cost for initial leak repair,

(f) Administrative and support cost for initial leak repair,

(g) Total initial leak repair costs,

(h) Annualized charges for initial leak repair.

6. Monitoring and Leak Repair Costs

For each source/service type within a model plant, the following average annual monitoring and leak repair costs (computed using the averages for the second turnaround) will be given:

(a) Monitoring labor costs,

(b) Labor costs for ongoing leak repair,

(c) Parts costs for ongoing leak repair,

(d) Administrative and support cost,

(e) Annualized charge for initial leak repair,

(f) Gross cost.

Model plant totals for each of the above parameters will also be printed.

If a complete tabled output listing is requested, the above costs will also be given for each year of the six-year period.

7. Cost-Effectiveness Data

The following average annual cost-effectiveness data are printed for each source/service type within a model plant (values are computed from the second turnaround averages):

(a) Mass emissions reduction (megagram per year),

(b) Recovery credit,

(c) Net costs,

(d) Gross cost-effectiveness (per megagram),

(e) Net cost-effectiveness (per megagram).

Model plant totals for each of the above parameters will also be given.

If a complete tabled output listing is requested, the above cost-effectiveness data will also be given for each year of the six-year period.

Examples of output from a model run can be found in Appendix C.

System Resources

A job requires approximately 35 CPU (Central Processing Unit) seconds on the EPA NCC system for the first case when confidence intervals are not requested. The job will require an additional 1 to 2 CPU seconds for each additional case. When confidence intervals are requested, the system requires approximately 50 CPU seconds for the first case and an additional 8 to 12 CPU seconds for each additional case.

Turnaround time depends on the system load (and initiation priority for a batch job) and can vary from several minutes to several hours.

SECTION 4

EXAMPLE SESSIONS

This section presents two example sessions using the LDAR program. The first example executes the LDAR program which submits the job to batch processing. The LDAR input data file is "NEW" and is therefore created during the session. The second example results in the LDAR model program running interactively. In this session, changes are made to a LDAR input data file previously cataloged. Data used for the sessions are for exemplary purposes and are not relevant for any particular situation.

Example 1: Submitting Batch Job

After logging onto the system and obtaining READY, the program was executed with the command

```
EXEC 'CN.EPASDJ.VOCF.LDAR.DATA(LDARB)' 'DEST(RMT15) DATA(CN.EPAiii.VOCF.NEW.DATA) STATUS(NEW)'
```

as described in Section 3. The following information was provided by the user:

Remote Destination: RMT15
Input Data Set Name: CN.EPAiii.VOCF.NEW.DATA
Status of the Input Data Set: NEW

For the remainder of the session, the user's entries will be preceded by the symbol "♦". This symbol is used here to distinguish user response from terminal queries or prompts, but is not provided during an actual session.

```
*** LEAK DETECTION AND REPAIR (LDAR) MODEL (IN SAS 79.6)
*** FOR RUNNING A BATCH JOB

RESPOND TO EACH PARAMETER DESCRIPTION WITH THE INPUT VALUE.

MODEL PLANT ID
* A
SOURCE TYPE
* VALVES
SERVICE TYPE
* LIGHT LIQUID
MONITORING INTERVAL (MONTHS)
* 3
TURNAROUND FREQUENCY (MONTHS)
* 24
EMISSION FACTOR (KG/HR/SOURCE)
* 0.027
LEAK OCCURRENCE RATE (% PER PERIOD)
* 1.27
INITIAL % LEAKING
* 22
EMISSIONS REDUCTION FOR UNSUCCESSFUL REPAIR (%)
* 62.6
EMISSIONS REDUCTION FOR SUCCESSFUL REPAIR (%)
* 97.7
EARLY LEAK RECURRENCE (% OF REPAIRS)
* 14
UNSUCCESSFUL REPAIR RATE (%)
* 10
UNSUCCESSFUL REPAIR RATE (%) AT TURNAROUND
* 0
TOTAL # OF SOURCES
* 260
MONITORING TIME PER SOURCE INSPECTION (MINUTES)
* 2
VISUAL MONITORING TIME PER SOURCE (MINUTES)
* 0
NUMBER OF VISUAL INSPECTIONS PER YEAR
* 0
REPAIR TIME PER SOURCE (MINUTES)
* 68
LABOR RATE ($/HOUR)
* 18
PARTS COST PER SOURCE ($)
* 0
A & S OVERHEAD COST FACTOR (%)
* 40
CAPITAL RECOVERY FACTOR (%)
* 16.3
RECOVERY CREDIT FOR EMISSIONS REDUCTION ($/MG)
* 215
```

Since the status of the input data file is "NEW" the user was immediately prompted for input data. Following each input parameter description, the user entered the parameter value.

```
  ARE MONTHLY FOLLOW-UPS TO BE PERFORMED BETWEEN THE
  PERIODIC SCREENING AND MAINTENANCE OF SOURCES?
• YES

  ARE CONFIDENCE INTERVALS ON EMISSION AND
  REDUCTION ESTIMATES DESIRED?
• YES

  RESPOND TO EACH PARAMETER DESCRIPTION WITH THE INPUT VALUE.

  STD ERROR OF INITIAL % LEAKING
• 2
  STD ERROR OF EMISSION REDUCTION DUE TO UNSUCCESSFUL REPAIR
• 10
  STD ERROR OF EMISSION REDUCTION DUE TO SUCCESSFUL REPAIR
• 4
  STD ERROR OF UNSUCCESSFUL REPAIR RATE
• 8
  STD ERROR OF EARLY LEAK RECURPENCE
• 5
  LOWER 95% CONFIDENCE LIMIT ON LEAK OCCURRENCE RATE
• 0.7
  UPPER 95% CONFIDENCE LIMIT ON LEAK OCCURRENCE RATE
• 1.0
  LOWER 95% CONFIDENCE LIMIT ON INITIAL EMISSION FACTOR
• 0.013
  UPPER 95% CONFIDENCE LIMIT ON INITIAL EMISSION FACTOR
• 0.054

  IS A COMPLETE TABLED OUTPUT LISTING DESIRED?
• YES

  DO YOU WANT TO ADD ANOTHER CASE?
• NO
```

The user selects the model options by replying appropriately to the queries. Since the user desired confidence intervals on emission and reduction estimates, he was prompted for variability input data. The user entered the desired parameter value following each parameter description.

```
  ENTER YOUR 6-CHARACTER USER ID
• EPAiii

  ENTER THE 12-CHARACTER ACCOUNT CODE AUTHORIZED FOR EPAiii
• VOCFENGRDRAD

  ENTER THE INITIATION PRIORITY FOR WHICH YOU WISH TO BE BILLED
• 1
```

Since the user did not wish to add another case, he has been prompted for his user ID, account code, and initiation priority. These values are required to submit the job to batch.

```
JOB EPASDJ(JOB04089) SUBMITTED
*** OUTPUT SENT TO PRINTER (RMT15)
```

The message above indicates that the job has been submitted to batch (Job #4089 for this example) and the hardcopy output has been routed to the printer (Remote 15 for this example). The session is now over.

Example 2: Interactive Run

This program was initiated with the command

```
EXEC 'CN.EPASDJ.VOCT.LOAD.DATA(LOAD)' 'DEST(RMT15) DATACN.EPAiii.VOCF.RUN.DATA STATUS(OLD)'
```

as described in Section 3. The information provided by the user is as follows:

```
Remote Destination:  RMT15
Input Data Set Name:  CN.EPAiii.VOCF.OLD.DATA
Status of the Input Data Set:  OLD
```

Since the input data set has already been cataloged the "STATUS(OLD)" keyword was not required in the above EXEC command. As with the first example interactive session, the user's entries will be preceded by the symbol "•". This symbol will not be used as a prompt during the actual session.

```
*** LEAK DETECTION AND REPAIR (LDAR) MODEL (IN SAS 79.6)
*** FOR RUNNING AN INTERACTIVE JOB

DOES YOUR INPUT DATA FILE PRESENTLY CONTAIN CASES
WHICH YOU WISH TO SAVE?
• YES
```

Since the status of the input data file is "OLD" the user had the option of deleting all cases on the file. The user did, however, wish to keep the cases and make changes to them.

```
MODEL PLANT A - GAS VALVES

IS THIS A CHANGE, A DELETION, OR IS IT OK?
• OK

MODEL PLANT A - LIGHT LIQUID VALVES

IS THIS A CHANGE, A DELETION, OR IS IT OK?
• DELETION

MODEL PLANT A - LIGHT LIQUID PUMP SEALS

IS THIS A CHANGE, A DELETION, OR IS IT OK?
• CHANGE

IF A CHANGE IS REQUIRED RESPOND WITH THE CORRECTED VALUE,
OTHERWISE PRESS RETURN.
• •
```

MODEL PLANT ID	A
SOURCE TYPE	PUMP SEALS
SERVICE TYPE	LIGHT LIQUID
MONITORING INTERVAL (MONTHS)	1
TURNAROUND FREQUENCY (MONTHS)	24
EMISSION FACTOR (KG/HR/SOURCE)	0.027
LEAK OCCURRENCE RATE (% PER PERIOD)	3.5
1.3	
INITIAL % LEAKING	10
12	
EMISSIONS REDUCTION FOR UNSUCCESSFUL REPAIR (%)	65
EMISSIONS REDUCTION FOR SUCCESSFUL REPAIR (%)	97.7
EARLY LEAK RECURRENCE (% OF REPAIRS)	14
UNSUCCESSFUL REPAIR RATE (%)	10
UNSUCCESSFUL REPAIR RATE (%) AT TURNAROUND	0
TOTAL # OF SOURCES	200
MONITORING TIME PER SOURCE INSPECTION (MINUTES)	10
VISUAL MONITORING TIME PER SOURCE (MINUTES)	0.5
NUMBER OF VISUAL INSPECTIONS PER YEAR	52
REPAIR TIME PER SOURCE (MINUTES)	960
LABOR RATE ($/HOUR)	18
PARTS COST PER SOURCE ($)	113
A & S OVERHEAD COST FACTOR (%)	40
CAPITAL RECOVERY FACTOR (%)	16.3
RECOVERY CREDIT FOR EMISSIONS REDUCTION ($/MG)	215

ARE CONFIDENCE INTERVALS ON EMISSION AND
REDUCTION ESTIMATES DESIRED?
NO

```
  IS A COMPLETE TABLED OUTPUT LISTING DESIRED?
• NO

  MODEL PLANT A - HEAVY LIQUID PUMP SEALS

  IS THIS A CHANGE, A DELETION, OR IS IT OK?
• OK

  DO YOU WANT TO ADD ANOTHER CASE?
• NO
```

During the session presented above, the user kept the first case as is, deleted the second case, changed the third case and kept the last case as is. He also chose not to add another case.

```
*** YOUR INTERACTIVE JOB IS NOW BEING PROCESSED
```

The message above indicates that the interactive job is being processed. During the processing of the job, the carriage will return several times before the following message is given.

```
*** OUTPUT SENT TO PRINTER (RMT15)
```

The interactive job is now complete and will output at the printer (Remote 15 for this example). The session is now over.

Appendix C contains the input and output files for the above interactive session examples.

REFERENCES

1. Williamson, H. J., L. P. Provost, and J. I. Steinmetz. Model for Evaluating the Effects of Leak Detection and Repair Programs on Fugitive Emissions. Technical Note, Radian Corporation, Austin, Texas, 1981.

2. SAS User's Guide, 1979 Edition. SAS Institute, Inc., 1979.

3. U.S. Environmental Protection Agency, Management Information and Data Systems Division. NCC-IBM User's Guide. National Computer Center, February, 1982 (revised September, 1982).

4. Langley, G. J. and R. G. Wetherold. Evaluation of Maintenance for Fugitive VOC Emission Control. EPA-600/52-81-080, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1981. 30 pp.

APPENDIX A

LDAR MODEL ENHANCEMENTS

In order to enhance the leak detection and repair model developed by Radian Corporation (Reference 1), the following items were added to the model's capabilities:

- a cost-effectiveness analysis,
- the option to evaluate 6-month, 9-month and one-year periodic inspection and repair programs with monthly reinspection of repaired sources within a period, and
- an emissions reduction estimate comparing the emission estimate resulting from the LDAR program to the emission estimate resulting when the LDAR program is not in effect.

This appendix documents the changes incorporated into the LDAR model developed by Radian Corporation (Reference 1).

Cost Inputs to the Model and Solutions

Definitions of Cost Inputs to the Model

The following are required cost inputs to the LDAR model:

TOTAL = total number of sources
MONITOR = monitoring time (minutes/source inspection)
VISUAL = visual monitoring time (minutes/source)
N = number of visual inspections per source per year
REPAIR = repair time (minutes/source)

LABOR = labor rate ($/hour)

PARTS = repair parts cost ($/source)

OCF = administrative and support overhead cost factor (%)

CRF = capital recovery factor (%)

CREDIT = recovery credit for emission reductions ($/megagram)

Initial Leak Repair Cost Estimates

The following initial leak repair cost estimates are derived from inputs to the model as shown below.

Parts Cost = (# sources)(initial leak frequency)(parts cost - $/source)

Labor Cost = (# sources)(initial leak frequency)(repair time - min/source)(labor rate - $/hr)(hr/60 min)

Administrative & Support (A&S) Overhead Cost = (labor cost) ·(overhead cost factor - %)/100

Total Costs = Parts Cost + Labor Cost + A&S Overhead Cost

Annualized Charges for Initial Leak Repair = (Total Costs)(capital recovery factor - %)/100

Annual Monitoring and Leak Repair Cost Estimates

Annual monitoring and leak repair cost estimates are derived from cost inputs and quantities computed by the model (i.e., fraction of sources screened in a given year) as shown below.

Monitoring Labor Costs in Year i = Instrument Monitoring Costs + Visual Monitoring Costs

= (# sources)(fraction monitored in year i)·(monitoring time - min/source)(labor rate - $/hr)·(hr/60 min)

+ (# sources)(# visual inspections per year per source)·(visual time - min/source)·(labor rate - $/hr)(hr/60 min)

Ongoing Repair Costs:

Parts Cost in Year i = (# sources)
·(fraction operated on in year i)
·(parts cost - $/source)

Labor Cost in Year i = (# sources)
·(fraction operated on in year i)
·(repair time - min/source)(labor rate - $/hr)(hr/60 min)

The fraction operated on in the 1st year does not include initial leak repairs.

A&S Overhead Costs in Year i

= (Monitoring Labor Costs in Yr i + Repair Labor Costs in Yr i)
(Overhead cost factor - %)/100

Gross Cost in Year i = Monitoring Cost in Yr i + Repair Parts Cost in Yr i + Repair Labor Cost in Yr i + A&S Overhead Cost in Yr i + Annualized Charge for Initial Leak Repair

Annual Cost Effectiveness Estimates

Annual cost effectiveness estimates are derived from model inputs and quantities computed by the model (i.e., mean emission rate in year i) as shown below.

Emission Reduction in Year i (Megagrams)

= (# sources)(initial emission factor (kg/hr) - mean emission rate in yr i (kg/hr))·(8760 hr/yr)(mg/1000 kg)

Recovery Credit in Year i = (Emission Reduction in yr i - mg)·
(recovery credit for emission reductions - $/mg)

Net Cost in Year i = Gross Cost in Year i - Recovery Credit in Year i

Gross Cost Effectiveness in Year i (per mg)

= Gross Cost in Yr i/Emission Reduction in Yr i

Net Cost Effectiveness in Year i (per mg)

= Net Cost in Yr i/Emission Reduction in Yr i

Alternative LDAR Programs

The modeled work practice described in Radian's Technical Note (Reference 1) has been generalized to include 6-month, 9-month and one year periodic inspection and repair programs with optional monthly follow-ups. This section documents changes and/or additions which can be made to Section 4 of the above-referenced technical note to incorporate the alternative LDAR programs.

Definitions of Inputs to the Model

The following are required inputs to the model for examining emission reductions due to LDAR:

IFL = fraction of sources leaking initially (from leak occurrence)

f_1 = one minus emissions reduction from unsuccessful repair, defined by $E_E = f_1 E_L$

f_2 = one minus emissions reduction from successful repair, defined by $E_P = f_2 E_L$

E_I = initial emission factor for all sources (kg/hr/source)

f_{E_1} = fraction of leaking sources for which attempted repair is unsuccessful

f_F = fraction of sources operating properly at the beginning that become leakers during a period (leak occurrence)

f_{E_2} = fraction of successfully repaired sources that experience early failure $\left(\frac{\text{number of early failures}}{\text{number of sources repaired}}\right)$

$f^1_{E_1} = f_{E_1}$ when a process turnaround occurs

TURN = frequency of turnaround (in months). TURN is restricted to multiples of the value of the PERIOD parameter.

PERIOD = frequency of periodic monitoring of sources (in months). PERIOD is restricted to one of the following values: 1, 3, 6, 9 or 12.

Definitions of Quantities Derived from the Inputs

The following quantities are derived from the inputs to the model:

E_L = average emission factor for sources leaking at or above the action level

E_P = average emission factor for sources leaking below the action level

E_E = average emission rate for sources which experienced early leak recurrences or for sources which were unsuccessfully maintained

Note that all of the quantities defined above are constants, i.e., are not functions of time. From these quantities, it is possible to write recursive equations which express the state of the system as a function of time. The "state of the system" at a given time consists of four numbers: the fractions of the sources in each of four categories (see below). The following are definitions of the variables which describe the state of the system as a function of time.

$R(t)$ = fractional reduction in emissions during the t^{th} period due to the maintenance

$F_L^-(t)$ = fraction of sources leaking (leaking at rate E_L) at the beginning of the t^{th} period, before maintenance (due to occurrence)

$F_L^+(t)$ = analogous quantity to $F_L^-(t)$, immediately after maintenance

$F_{E_1}^-(t)$ = fraction of sources which were unrepaired just before maintenance

$F_{E_1}^+(t)$ = analogous quantity to $F_{E_1}^-(t)$ just after maintenance

$F_{E_2}^-(t)$ = fraction of sources that were repaire and experienced early failure, just before maintenance

$F^{+}_{E_2}(t)$ = analogous quantity to $F^{-}_{E_2}(t)$, just after maintenance

$F^{-}_{p}(t)$ = fraction of sources which were non-leaking (that is, leaking below the action level) just before maintenance

$F^{+}_{p}(t)$ = fraction of sources which were non-leaking just after maintenance

Expressions for Intermediate Derived Quantities

The expressions for the intermediate derived quantities of E_L, E_E and E_p as they appear in the technical note (Reference 1) are not affected by the LDAR program generalization capability.

A set of recursive equations has been derived which can be used to express the state of the system at successive times t, in months. Separate equations apply for

(1) periods at which turnarounds are performed,
(2) periods at which regular periodic maintenance is performed, and
(3) the months between periods.

The equations for (1) and (2), above, appear in the technical note (Reference 1) under "Equations for Turnaround" and "Equations for Quarter," respectively. They are unaffected by the LDAR program generalization capability. Equations for months between periods are changed as given below.

Equations for Months Between Periods

For monthly maintenance at time t, the following eight equations apply:

The first four equations define the fraction of sources in each category just before monthly maintenance as a function of conditions just after the last maintenance (at the period or subsequent month after the period).

$$F_{E_1}^{-}(t) = F_{E_1}^{+}(t-1)$$

$$F_{E_2}^{-}(t) = F_{E_2}^{+}(t-1)$$

$$F_{P}^{-}(t) = F_{P}^{+}(t-1)\ (1-FF1)$$

$$F_{L}^{-}(t) = F_{L}^{+}(t-1) + F_{P}^{+}(t-1)\ FF1$$

where FF1 is a 30-day leak occurrence rate estimate based on f_F and modeled using the exponential distribution (Reference 4).

The following four equations define the fraction of sources in each category just after monthly maintenance as a function of conditions just before maintenance.

$$F_{E_1}^{+}(t) = F_{E_1}^{-}(t) + N_{op} f_{E_1}$$

N_{op} is the fraction of sources for which monthly maintenance is undertaken at time t. The equations for N_{op}, which are different for the first and subsequent months after the period, are given below.

Since unrepaired sources remain unrepaired until a turnaround, $F_{E_1}^{+}(t)$ is the fraction of unrepaired sources before monthly maintenance plus the fraction of sources for which maintenance was unsuccessful during the monthly maintenance.

$$F^+_{E_2}(t) = N_{op}(1-f_{E_1})f_{E_2} \quad [= F^-_{E_2}(t) \text{ if monthly maintenance is not done}]$$

$$F^+_P(t) = F^-_P(t) + N_{op}[1-f_{E_1} - (1-f_{E_1})f_{E_2}]$$

Note that the fraction $F^+_P(t)$ of sources leaking below the action level just after monthly maintenance is the corresponding fraction just before maintenance plus the fraction successfully repaired.

$$F^+_L(t) = 1 - F^+_{E_1}(t) - F^+_{E_2}(t) - F^+_P(t)$$

The quantity N_{op}, employed above, is obtained as follows for the first month after a period; the time at the period is t_o. Note that the time index is just an argumert in a set of functions; the symbol t_o is used here simply to indicate a specific time in the past.

If a turnaround was performed at the last period, N_{ck} is defined as follows:

$$N_{ck} = [F^-_L(t_o) + F^-_{E_2}(t_o) + F^-_{E_1}(t_o)]$$

If regular periodic maintenance was performed at the last period, N_{ck} is:

$$N_{ck} = [F^-_L(t_o) + F^-_{E_2}(t_o)]$$

In either case, N_{op} is defined as follows:

$$N_{op} = F^+_{E_2}(t_o) + N_{ck}[1-g - (1-g)f_{E_2}] \quad FF1$$

where g is $f^1_{E_1}$ if a turnaround was performed at the last period and f_{E_1} if regular periodic maintenance was performed.

Note that N_{ck} is the fraction of sources maintained at the beginning of the period. The quantity N_{op} is the fraction of the sources which had maintenance attempted at the first month. The sources with attempted maintenance include:

(1) early leakers after the last periodic maintenance,

(2) sources maintained at the period which are neither early leakers nor unrepaired, but which experienced leak recurrence.

The fraction screened each month between periods is the number operated on two months ago minus the fraction of those sources which are unrepaired.

Note: If the monthly maintenance is not done, set $N_{op} = N_{ck} = 0$ but calculate $F^{+}_{E_2}(t) = F^{-}_{E_2}(t)$, as indicated above, where t is the time at the month in question. This statement applies for maintenance at both the first and subsequent months after the period.

The quantity N_{op} is obtained as follows for the second, third, fourth, ... month after a period; the time at the period is t_o.

Define $N^{P}_{op} = N_{op}$ value from prior month and $N_{op}{}^{PP} = N_{op}{}^{P}$ value from prior month.

Fraction of sources operated on = N_{op} =

$$(N^{P}_{op})(1-f_{E_1})f_{E_2} + N^{P}_{op}[1-f_{E_1} - (1-f_{E_1})f_{E_2}]\ FF1 + [N_{op}{}^{PP} - N^{P}_{op} - N_{op}{}^{PP}g]\ FF1$$

where for the second month g is $f^{1}_{E_1}$ if a turnaround was performed at the

last period and f_{E_1} if regular periodic maintenance was performed; else for the third, fourth, ... month g is f_{E_1}.

Note that in this case N_{op} is the sum of

(1) the fraction of the sources which were early leakers after maintenance at the prior month,

(2) the fraction of the sources with maintenance attempted at the first month which were not unrepaired or early leakers, but became leakers during the month, and

(3) the fraction of sources with maintenance attempted for two months prior, excluding those with attempted maintenance at the prior month and those unrepaired two months prior, which became leakers during the prior month.

Fraction of Sources Screened

The fraction of sources screened is as follows:

(1) At a turnaround or regular periodic maintenance (time t):

$$1 - \bar{F}_{E_1}(t)$$

(2) at first month after period:

$$N_{ck}(1-g)$$

(3) at second, third, ... month after period:

$$N_{op}^{PP}(1-g) - N_{op}^{P} f_{E_1}$$

Fraction of Sources for Which Maintenance is Performed

The fraction of sources for which maintenance is performed is as follows:

(1) at turnaround (time t):

$$F_L^-(t) + F_{E_2}^-(t) + F_{E_1}^-(t)$$

(2) at regular periodic maintenance (time t):

$$F_L^-(t) + F_{E_2}^-(t)$$

(3) at the months following the period: N_{op}, defined above

Average Emission Factor for the n-Month Period Beginning at Time t:

$$\frac{1}{2n}\left\{\sum_{i=0}^{n-1}\left[F_L^+(t+i) + F_L^-(t+i+1)\right]E_L\right.$$
$$+\sum_{i=0}^{n-1}\left[F_{E_1}^+(t+i) + F_{E_1}^-(t+i+1) + F_{E_2}^+(t+i) + F_{E_2}^-(t+i)\right.$$
$$\left.\left.+ F_{E_2}^-(t+i+1)\right]E_E + \sum_{i=0}^{n-1}\left[F_p^+(t+i) + F_p^-(t+i+1)\right]E_p\right\}$$

Fractional Reduction in Emissions

The fractional reduction in emissions for this period due to the LDAR program (relative to initial emissions) is as follows:

$$\frac{\text{BEFORE - AFTER}}{\text{BEFORE}}$$

BEFORE = $\bar{F_L}(0)\ E_L + [1-\bar{F_L}(0)]E_P = E_I$

AFTER = given above.

Alternative Emission Reduction Estimate

In addition to the emission reduction estimate relative to initial emissions, an emission reduction estimate relative to emissions resulting when the LDAR program is not in effect is also computed by the LDAR program. This estimate may be useful when adequate initial emission data are not available for a situation. The schematic diagram (Figure A-1) demonstrates roughly how the "no LDAR program" comparison works for a two-year turnaround. For the "no LDAR program" ("uncontrolled") approach, leaking sources are repaired during a process turnaround.

Note that for this approach:

(1) "LDAR program" emissions are always less than or equal to "uncontrolled" emissions.

(2) "Initial" emissions may be less than or greater than "uncontrolled" emissions after the first turnaround. This relationship will depend on the initial fraction leaking/leak occurrence ratio primarily.

(3) Similarly to (2) for "initial" and "LDAR program" emissions.

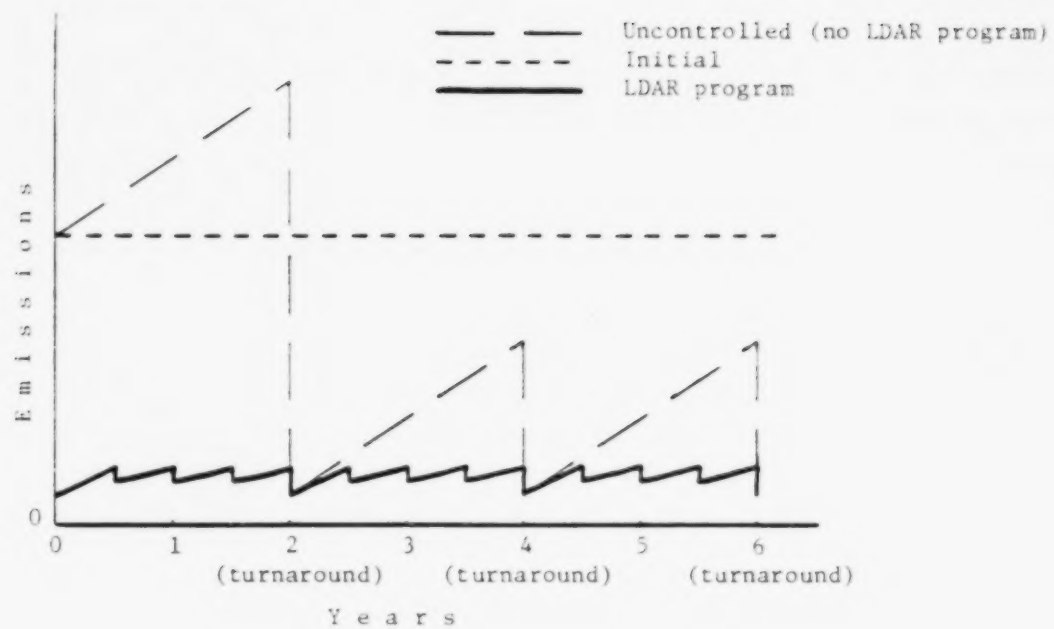

Figure A-1. Schematic diagram of emissions.

The fractional reduction in emissions for the period due to the LDAR program (relative to "uncontrolled" emissions) is as follows:

$$\frac{\text{BEFORE} - \text{AFTER}}{\text{BEFORE}}$$

BEFORE = average emission factor resulting when the LDAR program is not in effect

$$= (\text{MOFL})\ E_L + (1 - \text{MOFL})\ E_P$$

AFTER = average emission factor for the period as defined in the preceding section

where MOFL = average fraction of sources leaking over the period, E_L and E_P are as defined in the preceding section.

The average fraction of sources leaking over the n-month period beginning at time t (MOFL) is derived as follows:

$$\text{MOFL} = \sum_{i=0}^{n-1} \text{OFL}(t + i)/n$$

where OFL(t) = fraction of sources leaking at time t

$$= \text{FF}(t)[1-\text{FLEAK}(t)] + \text{FLEAK}(t)$$

and FF(t) = m-month occurrence rate estimate modeled using the exponential distribution (Reference 4), where m = number of months since the last turnaround

$$\text{FLEAK}(t) = \begin{cases} \text{initial fraction leaking, if at or prior to 1st turnaround} \\ \text{fraction of sources experiencing early leak recurrences immediately following the most recent turnaround} \quad \text{otherwise} \end{cases}$$

APPENDIX B

SOURCE PROGRAM LISTINGS

This appendix gives the source program listings of the LDAR model program and the various other programs which set up the input data files and executes the LDAR program. These programs are sequential files and members of the following partitioned data set (PDS):

CN.EPASDJ.VOCF.LDAR.DATA

The members of the above-named PDS and their functions are as follows:

MODEL — Programmed model which simulates the implementation of a LDAR program for six years.

SETUP — Sets up the LDAR input data file by interacting with the user.

SETJCL — Sets up the JCL input data file by interacting with the user. This member is used only when the job is being submitted to batch.

LDAR — Interactive program control. This member is a CLIST which contains the ALLOCATE commands and the CALL command required for running the LDAR model program interactively.

LDARB — Batch program control. This member is a CLIST which contains the ALLOCATE commands, CALL command and SUBMIT command required for submitting the LDAR model program to batch.

The first three PDS members listed above are Statistical Analysis System (SAS) programs. SAS is an integrated system for data management and statistical analysis (Reference 2).

A second data set, CN.EPASDJ.VOCF.LDAR.JCL.DATA, contains the JCL created by SETJCL. This file is used as an input data file and is re-created each time a LDAR batch job is submitted. An example of the form of this file can be found in Appendix C.

Table B-1. PDS Member: MODEL

```
00001 ************************************************************************;
00002 ************************************************************************;
00003 *              THIS STATISTICAL ANALYSIS SYSTEM (SAS) PROGRAM           *;
00004 *               ALLOWS THE USER TO EVALUATE THE IMPACT OF A             *;
00005 *              MAINTENANCE PROGRAM ON FUGITIVE EMISSIONS FROM           *;
00006 *                       CERTAIN IN-LINE SOURCES.                        *;
00007 *                                                                       *;
00008 *                                                                       *;
00009 *                          RADIAN CORPORATION                           *;
00010 *                             AUSTIN, TEXAS                             *;
00011 *                                                                       *;
00012 *                             AUGUST, 1982                              *;
00013 *                                                                       *;
00014 ************************************************************************;
00015 ************************************************************************;
00016 OPTIONS LS=132 PS=48  NONUMBER NODATE NOSOURCE NONOTES;
00017 ************************************************************************;
00018 *                                                                       *;
00019 *    IN ORDER TO PROPERLY IMPLEMENT THE PROGRAM THE FOLLOWING           *;
00020 *     INPUT PARAMETERS ARE REQUIRED:                                    *;
00021 *                                                                       *;
00022 *   TYPE= SOURCE TYPE IDENTIFICATION                                    *;
00023 *   SERVICE=SERVICE TYPE IDENTIFICATION                                 *;
00024 *   PLANT=PLANT IDENTIFICATION                                          *;
00025 *   IFL=PERCENT OF SOURCES LEAKING INITIALLY                            *;
00026 *   SE1=STANDARD ERROR OF IFL (NOT REQUIRED IF OPTION1=0)               *;
00027 *   F1=EMISSION REDUCTION FROM AN UNSUCCESSFUL REPAIR (%)               *;
00028 *   SE2=STANDARD ERROR OF F1 (NOT REQUIRED IF OPTION1=0)                *;
00029 *   F2=EMISSION REDUCTION FROM A SUCCESSFUL REPAIR (%)                  *;
00030 *   SE3=STANDARD ERROR OF F2 (NOT REQUIRED IF OPTION1=0)                *;
00031 *   FE1=PERCENT OF SOURCES WITH ATTEMPTED MAINTENANCE                   *;
00032 *       FOR WHICH THE REPAIR WAS NOT SUCCESSFUL                         *;
00033 *   SE4=STANDARD ERROR OF FE1 (NOT REQUIRED IF OPTION1=0)               *;
00034 *   FE2=PERCENT OF SUCCESSFULLY REPAIRED SOURCES THAT EXPERIENCE        *;
00035 *       EARLY FAILURE                                                   *;
00036 *   SE5=STANDARD ERROR OF FE2 (NOT REQUIRED IF OPTION1=0)               *;
00037 *   FF=PERCENT OF SOURCES OPERATING PROPERLY AT THE BEGINNING           *;
00038 *      THAT BECOME LEAKERS DURING A PERIOD.                             *;
00039 *   FFA=LOWER BOUND OF A TWO-TAILED 95% CONFIDENCE INTERVAL ON          *;
00040 *       FF (NOT REQUIRED IF OPTION1=0)                                  *;
00041 *   FFB=UPPER BOUND OF A TWO-TAILED 95% CONFIDENCE INTERVAL ON          *;
00042 *       FF (NOT REQUIRED IF OPTION1=0)                                  *;
00043 *   EI=INITIAL EMISSION FACTOR (KG/HR/SOURCE) FOR ALL SOURCES           *;
00044 *   EIA=LOWER BOUND OF A TWO-TAILED 95% CONFIDENCE INTERVAL ON          *;
00045 *       EI (NOT REQUIRED IF OPTION1=0)                                  *;
00046 *   EIB=UPPER BOUND OF A TWO-TAILED 95% CONFIDENCE INTERVAL ON          *;
00047 *       EI (NOT REQUIRED IF OPTION1=0)                                  *;
00048 *   TURN=FREQUENCY OF TURNAROUND IN MONTHS (DEFAULT IS 24 MONTHS).      *;
00049 *        TURN IS RESTRICTED TO MULTIPLES OF THE VALUE OF THE PERIOD     *;
```


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Table B-1. (Continued)

```
00050 *        PARAMETER.                                                    *;
00051 *    FE=THE VALUE OF FE1 WHEN A PROCESS TURNAROUND OCCURS (DEFAULT     *;
00052 *       VALUE IS ZERO)                                                 *;
00053 *    OPTION1=0, IF CONFIDENCE INTERVALS ON EMISSION AND REDUCTION      *;
00054 *               ESTIMATES ARE NOT DESIRED (DEFAULT VALUE);             *;
00055 *           =1, IF CONFIDENCE INTERVALS ARE DESIRED.                   *;
00056 *    OPTION2=0, IF ONLY SUMMARY TABLED OUTPUT IS DESIRED               *;
00057 *               (DEFAULT VALUE);                                       *;
00058 *           =1, IF COMPLETE TABLED OUTPUT IS DESIRED.                  *;
00059 *    OPTION3=0, IF MONTHLY FOLLOW-UPS ARE NOT TO BE PERFORMED          *;
00060 *               BETWEEN THE PERIODIC SCREENING AND MAINTENANCE         *;
00061 *               OF SOURCES (DEFAULT VALUE) --- THE FREQUENCY OF        *;
00062 *               THESE CHECKS MUST BE SPECIFIED (SEE 'PERIOD'           *;
00063 *               PARAMETER BELOW);                                      *;
00064 *           =1, IF MONTHLY FOLLOW-UPS ARE TO BE PERFORMED              *;
00065 *               BETWEEN THE PERIODIC SCREENING AND MAINT-              *;
00066 *               ENANCE OF SOURCES.                                     *;
00067 *    PERIOD=FREQUENCY (IN MONTHS) OF PERIODIC SCREENING AND            *;
00068 *           MAINTENANCE OF SOURCES (IF OPTION3=1 THEN PERIOD           *;
00069 *           DEFAULTS TO 3 .... ELSE PERIOD CAN BE SPECIFIED            *;
00070 *           AS ANY ONE OF THE FOLLOWING VALUES: 1, 3, 6, 9, OR 12)     *;
00071 *                                                                      *;
00072 *                 ************************************                 *;
00073 *                                                                      *;
00074 *     IN ORDER TO IMPLEMENT THE COSTING SECTION OF THE PROGRAM THE     *;
00075 *      FOLLOWING ADDITIONAL INPUT PARAMETERS ARE REQUIRED:             *;
00076 *                                                                      *;
00077 *    TOTAL=TOTAL POPULATION OF SOURCES                                 *;
00078 *    MONITOR=MONITORING TIME (MINUTES) PER SOURCE INSPECTION           *;
00079 *    VISUAL=VISUAL MONITORING TIME (MINUTES) PER SOURCE                *;
00080 *    REPAIR=REPAIR TIME (MINUTES) PER SOURCE                           *;
00081 *    PARTS=PARTS COST PER SOURCE                                       *;
00082 *    N=NUMBER OF VISUAL INSPECTIONS PER YEAR (PER SOURCE)              *;
00083 *        (DEFAULTS TO ZERO IF VISUAL=0)                                *;
00084 *    LABOR=LABOR RATE ($/HOUR)                                         *;
00085 *    CREDIT=RECOVERY CREDIT PER MEGAGRAM (MG) FOR EMISSION REDUCTION   *;
00086 *    OCF=OVERHEAD COST FACTOR (%)                                      *;
00087 *    CRF=CAPITAL RECOVERY FACTOR (%)                                   *;
00088 *                                                                      *;
00089 ************************************************************************;
00090 *;
00091 DATA _NULL_ ;
00092 FILE TERM;
00093 PUT /  '*** YOUR INTERACTIVE JOB IS NOW BEING PROCESSED ' ;
00094 DATA INPUT;
00095 INFILE OLD;
00096 INPUT TYPE=$20.  SERVICE=$20. PLANT=$20. IPL= SE1= F1= SE2= F2= SE3=
00097       FE1= SE4= FE2= SE5= FF= FFA= FFB= EI= EIA= EIB= TURN= FE=
00098       OPTION1= OPTION2= OPTION3= PERIOD= TOTAL= MONITOR= VISUAL=
00099       REPAIR= PARTS= LABOR= CREDIT= OCF= CRF= N=  ;
```

Table B-1. (Continued)

```
00100 IF OPTION1=. THEN OPTION1=0;
00101 IF OPTION2=. THEN OPTION2=0;
00102 IF OPTION3=. THEN OPTION3=0;
00103 IF OPTION3=1 AND PERIOD=. THEN PERIOD=3;
00104 IF VISUAL=0 THEN N=0;
00105 IF TURN=. THEN TURN=24;
00106 IF FE=. THEN FE=0;
00107    NTRIAL=200;
00108 RETAIN CHECK 0;
00109 ARRAY _PCT (K) IFL SE1 F1 SE2 F2 SE3 FE1 SE4 FE2 SE5 FF FFA FFB FE;
00110 DO OVER _PCT;   _PCT=_PCT/100;   END;
00111 F1=1-F1;  F2=1-F2;
00112 PROC SORT DATA=INPUT; BY PLANT TYPE SERVICE;
00113 *;
00114 ************************************************************************;
00115 *  THE FOLLOWING CODE PRINTS OUT THE INPUT DATA FOR EACH SOURCE,      *;
00116 *  UNIT, AND SERVICE TYPE COMBINATION.                                *;
00117 ************************************************************************;
00118 *;
00119 DATA _NULL_; SET INPUT  ; BY PLANT TYPE SERVICE;
00120 FILE PRINT  HEADER=H NOTITLES;
00121 ARRAY _PCT (K) IFL SE1 F1 SE2 F2 SE3 FE1 SE4 FE2 SE5 FF FFA FFB FE;
00122 F1=1-F1;  F2=1-F2;
00123 DO OVER _PCT;   _PCT=_PCT*100;   END;
00124 ARRAY A SE1-SE5 FFA FFB EIA EIB;
00125 IF OPTION1=0 THEN DO OVER A; A=.; END;
00126 IF FIRST.SERVICE THEN PUT _PAGE_;
00127 N=-1;
00128 PUT ///
00129     +5 'FOR EXAMINING EMISSION REDUCTIONS DUE TO LDAR' @;
00130     IF OPTION1=1 THEN PUT '*' @; PUT ':' /
00131     +5 47*'_' //  +10 'MONITORING INTERVAL (MONTHS)'
00132     @66 PERIOD @; IF OPTION3=1 THEN PUT @71 '**' @;
00133     PUT /  +10 'TURNAROUND FREQUENCY (MONTHS)'
00134     @66 TURN /  +10 'EMISSION FACTOR (KG/HR/SOURCE)'
00135     @66 EI @; IF OPTION1=1 THEN PUT  @75 '(' EIA +M ',' +1 EIB +M ')'
00136     @; PUT  / +10 'LEAK OCCURRENCE RATE (% PER PERIOD)'
00137     @66 FF  @; IF OPTION1=1 THEN PUT @75 '(' FFA +M ',' +1 FFB +M ')'
00138     @; PUT / +10 'INITIAL % LEAKING' @66 IFL
00139     @; IF OPTION1=1 THEN PUT @75 '(' SE1 +M ')' @;  PUT
00140     / +10 'EMISSIONS REDUCTION FOR UNSUCCESSFUL REPAIR (%)'
00141     @66 F1  @; IF OPTION1=1 THEN PUT @75 '(' SE2 +M ')' @; PUT /
00142     +10 'EMISSIONS REDUCTION FOR SUCCESSFUL REPAIR (%)'
00143     @66 F2  @; IF OPTION1=1 THEN PUT @75 '(' SE3 +M ')' @; PUT /
00144     +10 'EARLY LEAK RECURRENCE (% OF REPAIRS)'
00145     @66 FE2   @; IF OPTION1=1 THEN PUT @75 '(' SE5 +M ')' @; PUT /
00146     +10 'UNSUCCESSFUL REPAIR RATE (%)'
00147     @66 FE1  @; IF OPTION1=1 THEN PUT @75 '(' SE4 +M ')' @; PUT /
00148     +10 'UNSUCCESSFUL REPAIR RATE (%) AT TURNAROUND'
00149     @66 FE   ///
```


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Table B-1. (Continued)

```
00150     +5 'FOR EXAMINING THE COSTS OF LOAR:'  / +5 31*'-' //
00151     +10 'TOTAL NUMBER OF SOURCES'  @66 TOTAL  /
00152     +10 'MONITORING TIME PER SOURCE INSPECTION (MINUTES)'
00153     @66 MONITOR  /
00154     +10 'VISUAL MONITORING TIME PER SOURCE (MINUTES)'
00155     @66 VISUAL  /
00156     +10 'NUMBER OF VISUAL INSPECTIONS PER YEAR'  @66 N   /
00157     +10 'REPAIR TIME PER SOURCE (MINUTES)'
00158     @66 REPAIR   /
00159     +10 'LABOR RATE ($/HOUR)'  @66 LABOR   /
00160     +10 'PARTS COST PER SOURCE ($)' @66 PARTS   /
00161     +10 'ADMINISTRATIVE & SUPPORT OVERHEAD COST FACTOR (%)'
00162     @66 OCF   /
00163     +10 'CAPITAL RECOVERY FACTOR (%)' @66 CRF  /
00164     +10 'RECOVERY CREDIT FOR EMISSIONS REDUCTION ($/MG)'
00165     @66 CREDIT  //; IF OPTION1=1 OR OPTION3=1 THEN
00166     PUT +4 13*'-';  IF OPTION1=1 THEN PUT /
00167     +5 '* VALUES IN PARENTHESES ARE EITHER THE STANDARD ERROR '
00168      OF THE ESTIMATE'  /  +7
00169     'OR THE APPROXIMATE 95% CONFIDENCE BOUNDS ON THE PARAMETER.' ;
00170     IF OPTION3=1 THEN PUT / +4 '** WITH MONTHLY FOLLOW-UPS.' ;
00171 RETURN;
00172 H:  PUT // @44 'I N P U T   D A T A' //
00173     +49 'PLANT' +1 PLANT /
00174     @43 '(FOR ' SERVICE TYPE +M ')';
00175 RETURN;
00176 *;
00177 ************************************************************************;
00178 * THE FOLLOWING MACRO (DEVELOP) CALCULATES EMISSION RATES AS A        *;
00179 *     FUNCTION OF TIME (IN MONTHS)                                    *;
00180 ************************************************************************;
00181 *;
00182 MACRO  DEVELOP
00183 ARRAY V(L) FE11 FE21 FP1 FL1;  ARRAY X0(L) T0FE11 T0FE21 T0FP1 T0FL1;
00184 ARRAY X2(S) T2FE12 T2FE22 T2FP2 T2FL2 T2FE11 T2FE21 T2FP1 T2FL1;
00185 ARRAY X1(S) T1FE12 T1FE22 T1FP2 T1FL2 T1FE11 T1FE21 T1FP1 T1FL1;
00186 ARRAY  X3(S) T3FE12 T3FE22 T3FP2 T3FL2 T3FE11 T3FE21 T3FP1 T3FL1;
00187 ARRAY  X4(S) T4FE12 T4FE22 T4FP2 T4FL2 T4FE11 T4FE21 T4FP1 T4FL1;
00188 ARRAY  X5(S) T5FE12 T5FE22 T5FP2 T5FL2 T5FE11 T5FE21 T5FP1 T5FL1;
00189 ARRAY  X6(S) T6FE12 T6FE22 T6FP2 T6FL2 T6FE11 T6FE21 T6FP1 T6FL1;
00190 ARRAY  X7(S) T7FE12 T7FE22 T7FP2 T7FL2 T7FE11 T7FE21 T7FP1 T7FL1;
00191 ARRAY  X8(S) T8FE12 T8FE22 T8FP2 T8FL2 T8FE11 T8FE21 T8FP1 T8FL1;
00192 ARRAY  X9(S) T9FE12 T9FE22 T9FP2 T9FL2 T9FE11 T9FE21 T9FP1 T9FL1;
00193 ARRAY  X10(S) T10FE12 T10FE22 T10FP2 T10FL2 T10FE11 T10FE21 T10FP1
00194               T10FL1;
00195 ARRAY  X11(S) T11FE12 T11FE22 T11FP2 T11FL2 T11FE11 T11FE21 T11FP1
00196               T11FL1;
00197 ARRAY  X12(S) T12FE12 T12FE22 T12FP2 T12FL2 T12FE11 T12FE21 T12FP1
00198               T12FL1;
00199 ARRAY X(L) TFE12 TFE22 TFP2 TFL2;
```

Table B-1. (Continued)

```
00200 ARRAY XX(SS) X X1-X12;
00201 ARRAY YY(L) FE12 FE22 FP2 FL2;
00202 ARRAY Y(S) FE12 FE22 FP2 FL2 FE11 FE21 FP1 FL1;
00203 ARRAY FS(T) FS1-FS72;  ARRAY FM(T) FM1-FM72;
00204 ARRAY LK(T) LEAK1-LEAK72;  ARRAY RD(T) REDUCT1-REDUCT72;
00205 ARRAY AFE12(T) FE12_1-FE12_72;  ARRAY AFE22(T) FE22_1-FE22_72;
00206 ARRAY AFP2(T) FP2_1-FP2_72;  ARRAY AFL2(T) FL2_1-FL2_72;
00207 ARRAY AFE11(T)  FE11_1-FE11_72; ARRAY AFE21(T) FE21_1-FE21_72;
00208 ARRAY AFP1(T) FP1_1-FP1_72;  ARRAY AFL1(T) FL1_1-FL1_72;
00209 ARRAY OFL (T) OFL1-OFL72;
00210 GAMMA=-LOG(1-FF/100)/(30.4*PERIOD);
00211 FF1=100*(1-EXP(-30.4*GAMMA));
00212 EL=EI/(IFL+(1-IFL)*F2);  E1=F1*EL;   E2=F2*EL;
00213 FE11=0;  FE21=0;  FL1=IFL ;  FP1=1-FL1;
00214 FE12=(1-FP1)*FE;
00215 FE22=(1-FP1)*(1-FE)*FE2;
00216 FP2=1-FE12-FE22;  FL2=0;        IFS=1;   IFM=IFL;
00217 DO OVER YY;  X=YY;  X0=V;   END;
00218 FE11_0=0;  FE21_0=0;  FL1_0=IFL;   FP1_0=1-FL1_0;
00219 FE12_0=(1-FP1_0)*FE;
00220 FE22_0=(1-FP1_0)*(1-FE)*FE2;
00221   FP2_0=1-FE12_0-FE22_0;  FL2_0=0;
00222 *-------------------------------------*;
00223 *     BEGINS LOOP ON TIME PARAMETER     *;
00224 *-------------------------------------*;
00225 DO T=1 TO 72;
00226 Q=MOD(T,PERIOD);  YR=MOD(T,TURN);
00227 IF Q NE 0 THEN SS=Q; ELSE IF Q=0 THEN SS=PERIOD;
00228 S=1;L=1;FE11=XX;
00229 S=2;L=2;FE21=XX;
00230 S=3;L=3;FP1=XX*(1-FF1 );XFP2=XX;
00231 S=4;L=4;FL1=XX+XFP2*FF1 ;
00232 *-----------------------------------------------------------*;
00233 IF Q NE 0 THEN DO;                                          *;
00234 *-----------------------------------------*;                *;
00235 IF OPTION3=1 THEN DO;                      *;               *;
00236 IF (YR=1 OR YR=2) THEN DO;                 *;               *;
00237 NCK=TOFL1+TOFE21+TOFE11;                   *;               *;
00238 G=FE;  END;                          *-------------*;      *;
00239 ELSE IF Q=1 OR Q=2 THEN DO;          *  IF MONTHLY  *;      *;
00240 NCK=TOFL1+TOFE21;G=FE1;END;          *  FOLLOW-UPS  *;      *;
00241 ELSE IF Q>2 THEN DO;                 *-------------*;      *;
00242   NCK=NOPPP;  G=FE1;                             *;        *;
00243 END;                                           *;        *;
00244 IF Q=1 THEN DO;                                 *;  *-----------------*;
00245 NOP=TFE22*NCK*(1-G-(1-G)*FE2)*FF1;              *;  *  EQUATIONS FOR  *;
00246 NOPP=NOP; FS=NCK*(1-G);  NOPPP=NOPP;            *;  *  MONTHS BETWEEN *;
00247 END;                                           *;  *     PERIODS     *;
00248 IF Q>=2 THEN DO;                               *; .*-----------------*;
00249 NOP=(NOPP*(1-FE1)*FE2)+NOPP*(1-FE1-(1-FE1)*FE2)*FF1
```


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Table B-1. (Continued)

```
00250      +(NCK-NOPP-NCK*G)*FF1 ;                    *;          *;
00251 FS=NCK*(1-G)-NOPP*FE1;                          *;          *;
00252 NOPPP=NOPP;  NOPP=NOP;                          *;          *;
00253 END;                                            *;          *;
00254 FE22=NOP*(1-FE1)*FE2; FM=NOP;                    *;          *;
00255 END;                                            *;          *;
00256 *-----------------------------------------------*;          *;
00257                                        *---------------*;    *;
00258 ELSE DO;                               *      IF       *;    *;
00259   NOP=0;NCK=0;FE22=FE21;FS=0;FM=0;      *  NO MONTHLY   *;    *;
00260 END;                                    *  FOLLOW-UPS   *;    *;
00261                                        *---------------*;    *;
00262 *-----------------------------------------------*;          *;
00263 FE12=FE11+NOP*FE1;                                          *;
00264 FP2=FP1+NOP*(1-FE1-(1-FE1)*FE2);                           *;
00265 FL2=1-FE12-FE22-FP2;                                       *;
00266 SS=Q+1; DO S=1 TO 8;  XX=Y;  END;                         *;
00267 END;                                                      *;
00268 *--------------------------------------------------------------;
00269 *-------------------------------------------------------------------*;
00270 ELSE IF Q=0 THEN DO;                                              *;
00271 *-----------------------------------------*;                      *;
00272 IF YR=0 THEN DO;                  *-----------------*;           *;
00273 FE12=(1-FP1)*FE;                  *  EQUATIONS AT   *;           *;
00274 FE22=(1-FP1)*(1-FE)*FE2;          *   TURNAROUND    *;           *;
00275 END;                              *-----------------*;           *;
00276 *-----------------------------------------*;                      *;
00277 ELSE DO;                          *-----------------*;           *;
00278 FE12=FE11+(FE21+FL1)*FE1;         *  EQUATIONS NOT  *;           *;
00279 FE22=(FE21+FL1)*(1-FE1)*FE2;      *  AT TURNAROUND  *;           *;
00280 END;                              *-----------------*;           *;
00281 *-----------------------------------------*;                      *;
00282 FP2=1-FE12-FE22;                                                 *;
00283 FL2=0;                                                          *;
00284 DO OVER V;  XQ=V;  END;                                         *;
00285 SUMEL=0;  SUMEE=0;  SUMEP=0;                                    *;
00286 DO SS=2 TO PERIOD;                                              *;
00287 DO S=4,8;                                          *-------------*;
00288 SUMEL=SUM(SUMEL,XX);                               *  EQUATIONS  *;
00289 END;                                               *     FOR     *;
00290 DO S=1,2,5,6;                                      *   PERIOD    *;
00291 SUMEE=SUM(SUMEE,XX);                               *-------------*;
00292 END;                                                    *;
00293 DO S=3,7;                                              *;
00294 SUMEP=SUM(SUMEP,XX);                                   *;
00295 END;                                                    *;
00296      END;                                              *;
00297 SUMEL=SUMEL+TFL2*TOFL1;                                 *;
00298 SUMEE=SUMEE+TFE12*TOFE11+TFE22*TOFE21;                  *;
00299 SUMEP=SUMEP+TFP2*TOFP1;                                 *;
```

Table B-1. (Continued)

```
00300 LK=((SUMEL*EL)+(SUMEE*EE)+(SUMEP*EP))/(2*PERIOD);                    *;
00301 RD=(EI-LK)/EI;                                                       *;
00302 DO OVER YY;  X=YY;  END;                                             *;
00303 FS=1-FE11; IF YR=0 THEN FM=FL1+FE21+FE11;ELSE FM=FL1+FE21;           *;
00304 AFE12=TFE12; AFE22=TFE22; AFP2=TFP2; AFE11=TOFE11;                   *;
00305 AFE21=TOFE21; AFL2=TFL2; AFP1=TOFP1; AFL1=TOFL1;                     *;
00306 END;                                                                 *;
00307 *-----------------------------------------------------------------*;
00308 IF YR=0 THEN YR2=TURN; ELSE YR2=YR;  YR1=YR2-1;
00309 FFT1=100*(1-EXP(-30.4*GAMMA*(R1)));   FFT2=100*(1-EXP(-30.4*GAMMA*(R2)));
00310 FF1=MEAN(FFT1,FFT2);
00311 IF YR=TURN THEN FLEAK=IFL;
00312 OFL=(FF1*(1-FLEAK))+FLEAK;
00313 IF YR=0 THEN FLEAK=FE22;
00314 END;
00315 *-----------------------------------------*;
00316 *     END OF LOOP ON TIME PARAMETER       *;
00317 *-----------------------------------------*;
00318 *-----------------------------------------*;
00319 ARRAY LL(M) L1-L72; ARRAY R(M) R1-R72; ARRAY BFE12(M) FE12_1-FE12_72;
00320 ARRAY BFE22(M) FE22_1-FE22_72;  ARRAY BFP2(M) FP2_1-FP2_72;
00321 ARRAY BFL2(M) FL2_1-FL2_72;  ARRAY BFE11(M) FE11_1-FE11_72;
00322 ARRAY BFE21(M) FE21_1-FE21_72;  ARRAY BFP1(M) FP1_1-FP1_72;
00323 ARRAY BFL1(M)  FL1_1-FL1_72;  ARRAY OR(M) OR1-OR72;
00324 ARRAY MOFL(M) MOFL1-MOFL72;
00325 M=0;
00326 DO I=PERIOD TO 72 BY PERIOD;
00327    M=M+1; LL=LK; R=RD; BFE12=AFE12; BFE22=AFE22; BFP2=AFP2; BFL2=AFL2;
00328    BFE11=AFE11; BFE21=AFE21; BFP1=AFP1; BFL1=AFL1;  END;
00329 I=0;  M=0;  SUM=0;
00330 NO=72/PERIOD;
00331 DO I=1 TO 72;
00332 SUM=SUM(SUM,OFL);
00333 I=I+1;  IF I=PERIOD THEN DO; M=M+1; MOFL=SUM/PERIOD; I=0; SUM=0; END;
00334 END;
00335 DO M=1 TO NO;
00336 OR=(MOFL*(EL-EP)+EP-LL)/(MOFL*(EL-EP)+EP);
00337 END;
00338 KEEP TYPE SERVICE PLANT L1-L72 R1-R72 FE12_0-FE12_72 FE22_0-FE22_72
00339      FP2_0-FP2_72 FL2_0-FL2_72 FE11_0-FE11_72 FE21_0-FE21_72 OR1-OR72
00340      FP1_0-FP1_72 FL1_0-FL1_72 IFS FS1-FS72 IFM FM1-FM72 EL EE EP
00341      IFL F1 F2 PERIOD NTRIAL OPTION2 TOTAL PARTS LABOR CREDIT MONITOR
00342      VISUAL REPAIR N OLF CRF TURN;
00343 %
00344 *;
00345 ***********************************************************************;
00346 *  THE FOLLOWING CODE COMPUTES AND PRINTS OUT THE TOTAL FRACTION      *;
00347 *  OF SOURCES SCREENED AND OPERATED ON OVER EACH YEAR OF THE SIX      *;
00348 *  YEAR MAINTENANCE PROGRAM.                                          *;
00349 ***********************************************************************;
```

Table B-1. (Continued)

```
00350 *;
00351 DATA RAW; SET INPUT (DROP=SE1-SE3 FFA FFB EIA EIB);
00352 _DEVELOP;
00353 DATA FSFM; SET RAW(KEEP=TYPE SERVICE PLANT IFS FS1-FS72 IFM FM1-FM72
00354    TOTAL PARTS LABOR CREDIT MONITOR VISUAL N REPAIR OCF CRF TURN
00355    OPTION2 L1-L72 PERIOD);
00356 BY PLANT TYPE SERVICE;
00357 FILE PRINT N=PS HEADER=H NOTITLES;
00358 M=-1;
00359 ARRAY  SUMFS (J) SUMFS1-SUMFS6;  ARRAY  SUMFM (J) SUMFM1-SUMFM6;
00360 SUMFS1=SUM(OF IFS FS1-FS12); SUMFM1=SUM(OF IFM FM1-FM12);
00361 SUMFS2=SUM(OF FS13-FS24); SUMFM2=SUM(OF FM13-FM24);
00362 SUMFS3=SUM(OF FS25-FS36); SUMFM3=SUM(OF FM25-FM36);
00363 SUMFS4=SUM(OF FS37-FS48); SUMFM4=SUM(OF FM37-FM48);
00364 SUMFS5=SUM(OF FS49-FS60); SUMFM5=SUM(OF FM49-FM60);
00365 SUMFS6=SUM(OF FS61-FS72); SUMFM6=SUM(OF FM61-FM72);
00366 LEAKS=TOTAL*IFM;
00367 IPC=LEAKS*PARTS;
00368 ILC=LEAKS*REPAIR*LABOR/60;
00369 IOC=ILC*OCF/100;
00370 TIRC=IPC+ILC+IOC;
00371 AC=TIRC*CRF/100;
00372 ARRAY _MC (J) MC1-MC6;  ARRAY  LC (J) LC1-LC6;  ARRAY  PC (J) PC1-PC6;
00373 ARRAY _TC (J) TC1-TC6;  ARRAY  OC (J) OC1-OC6;
00374 DO OVER  MC;
00375    _MC=(TOTAL* SUMFS*MONITOR*LABOR/60) + (TOTAL*VISUAL*N*LABOR/60);
00376    _PC=TOTAL* SUMFM*PARTS;
00377    LC=TOTAL* SUMFM*LABOR*REPAIR/60;
00378    _OC=(_MC+_LC)*OCF/100;
00379    _TC= MC+ PC+ LC+ OC+AC;
00380 END;
00381 PC1=PC1-(TOTAL*IFM*PARTS);
00382 LC1=LC1-(TOTAL*IFM*LABOR*REPAIR/60);
00383 OC1=(MC1+LC1)*OCF/100;
00384 TC1=MC1+PC1+LC1+OC1+AC;
00385 TPC=SUM(OF TC1-TC6);  TMC=SUM(OF MC1-MC6);
00386 TLC=SUM(OF LC1-LC6);
00387 TPC=SUM(OF PC1-PC6);  TOC=SUM(OF OC1-OC6);
00388 TAC=6*AC;
00389 NN=CEIL(TURN/12);  NN1=NN+1;  NN2=2*NN;
00390 ARRAY _AVG (I) AVG1-AVG5;  ARRAY  SUM (I) SUM1-SUM5;
00391 DO OVER  SUM;   SUM=0;  END;
00392 DO J=NN1 TO NN2;
00393 SUM1=SUM(SUM1, MC);  SUM2=SUM(SUM2, PC);
00394 SUM3=SUM(SUM3, LC);  SUM4=SUM(SUM4, OC);
00395 SUM5=SUM(SUM5, TC);
00396 END;
00397 DO OVER  AVG;   AVG= SUM/(NN2-NN1+1);  END;
00398 IF OPTION2=0 THEN RETURN;
00399 SUMFS1=SUMFS1-IFS;  SUMFM1=SUMFM1-IFM;
```


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Table B-1. (Continued)

```
00400 IF FIRST.SERVICE THEN PUT _PAGE_;
00401 PUT #11 @38 'TOTAL FRACTION OF' +6 'TOTAL FRACTION OF' / @26 'YEAR' @38
00402    'SOURCES SCREENED' +6 'SOURCES OPERATED ON' / @23 60*'-' ///;
00403 PUT @25 'INITIAL' @43 IFS 7.4 +16 IFM 7.4 ///;
00404 DO J=1 TO 6;
00405 PUT @27 J 2. @43 _SUMFS 7.4 +16 _SUMFM 7.4 ///;
00406 END;
00407 RETURN;
00408 H:  PUT //// @13 'SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND
00409      'OPERATED ON FOR' +1 TYPE +1 '/' / @38 SERVICE 'SERVICE' +1
00410      'BY YEAR - PLANT' PLANT ///     ;
00411 RETURN;
00412 *;
00413 ********************************************************************;
00414 *  THE FOLLOWING CODE PRINTS OUT THE TOTAL FRACTION OF SOURCES      *;
00415 *  SCREENED AND OPERATED ON PER TURNAROUND                          *;
00416 ********************************************************************;
00417 *;
00418 DATA _NULL_; SET RAW(KEEP=TYPE SERVICE PLANT IFS FS1-FS72 IFM TURN
00419                         FM1-FM72 PERIOD);
00420 BY PLANT TYPE SERVICE;
00421 FILE PRINT HEADER=H NOTITLES;
00422 N=-1;
00423 ARRAY _SUMFS (K) SUMFS1-SUMFS24;  ARRAY _FS (I) FS1-FS72;
00424 ARRAY _SUMFM (K) SUMFM1-SUMFM24;  ARRAY _FM (I) FM1-FM72;
00425 SUM1=0;  SUM2=0;
00426 I=0;  K=0;
00427 DO I=1 TO 72;
00428 SUM1=SUM(SUM1, _FS);  SUM2=SUM(SUM2, _FM);
00429 I=I+1;
00430 IF I=TURN THEN DO; K=K+1; _SUMFS=SUM1; _SUMFM=SUM2;
00431    I=0; SUM1=0; SUM2=0;
00432 END;
00433 END;
00434 SUMFS1=SUMFS1+IFS;  SUMFM1=SUMFM1+IFM;
00435 N=K;
00436 IF FIRST.SERVICE THEN PUT _PAGE_;
00437 PUT #14 @23 'TURNAROUND' @38 'TOTAL FRACTION OF' +6
00438      'TOTAL FRACTION OF' /  @25 'PERIOD' @38 'SOURCES SCREENED'
00439     +6 'SOURCES OPERATED ON' /  @20 65*'-'  ///   ;
00440 DO K=1 TO N;
00441 PUT @27 K 2.  @43 _SUMFS 7.4 +16 _SUMFM 7.4 /;
00442 END;
00443 RETURN;
00444 H:  PUT //// @13 'SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND
00445      'OPERATED ON FOR' TYPE +1 '/' / @38 SERVICE 'SERVICE'
00446      'BY TURNAROUND - PLANT' PLANT ///   ;
00447 RETURN;
00448 *;
00449 ********************************************************************;
```

Table B-1. (Continued)

```
00450 *  THE FOLLOWING CODE SIMULATES SCREENING AND EMISSIONS DATA USING   *;
00451 *  SAMPLE VALUES (INPUT) IN ORDER TO ESTIMATE CONFIDENCE INTERVALS   *;
00452 *    ON EMISSIONS AND EMISSIONS REDUCTION.                           *;
00453 ************************************************************************;
00454 *;
00455 DATA GENERATE: SET INPUT;
00456 ARRAY _SD(Z)  SD1  SD2;
00457 SD1=5896351;  SD2=3254357;
00458 ARRAY U(Z) FF EI;
00459 ARRAY A(Z) FFA EIA;  ARRAY B(Z) FFB EIB;
00460 ARRAY H1(Z) FFH1 EIH1; ARRAY H2(Z) FFH2 EIH2;  ARRAY H3(Z) FFH3 EIH3;
00461 ARRAY C1(Z) FFC1 EIC1;  ARRAY C2(Z) FFC2 EIC2;  ARRAY C3(Z) FFC3 EIC3;
00462 ARRAY D2(Z) FFD2 EID2;  ARRAY D3(Z) FFD3 EID3;
00463 ARRAY YO(Z) FFYO EIYO;  ARRAY RVAR(Z) RV FF RV EI;
00464 ARRAY PT(Z) FFPT EIPT;  ARRAY CO(Z) FFCO EICO;
00465 ARRAY  SEED(I)  SEED1-SEED5;
00466 SEED1=4515513; SEED2=8035411; SEED3=2509367; SEED4=2584463;
00467 SEED5=2585067;
00468 ARRAY MU(I)  IFL F1 F2 FE1 FE2;
00469 ARRAY RV(I)  RV_IFL RV_F1 RV_F2 RV_FE1 RV_FE2;
00470 ARRAY SE(I) SE1-SE5;
00471 IF OPTION1=1 THEN DO;
00472 DO OVER A;  H1=.025/A;  C1=U-((A**2)*H1)/2-((((B+3*A)**2)-(B**2))*H1/6);
00473              C2=((U**2)-(A**2))/2;  D2=U-A;
00474              C3=((B**2)-(U**2))/2;  D3=B-U;
00475           H3=((C1*D2)-(.95*C2))/((C3*D2)-(C2*D3)); H2=(.95-(D3*H3))/D2;
00476           PT=0.025*H2*(U-A);      END;
00477 DO J=1 TO NTRIAL;
00478 DO OVER MU;  RV=MU+SE*NORMAL(_SEED);         END;
00479 DO OVER YO;  YO=UNIFORM(_SD);
00480 IF 0<=YO<.025 THEN RVAR=YO/H1;
00481   ELSE IF .025<=YO<PT THEN DO; CO=.025-H2*A; RVAR=(YO-CO)/H2; END;
00482   ELSE IF PT<=YO<.975 THEN DO; CO=.975-H3*B; RVAR=(YO-CO)/H3; END;
00483   ELSE IF .975<=YO<=1 THEN DO; CO=1-(H1/3)*(B+3*A); RVAR=3+(YO-CO)/H1;
00484        END;
00485 END;
00486 OUTPUT;END;END;ELSE IF OPTION1=0 THEN DO;
00487 DO OVER MU;RV=MU;END;
00488 DO OVER  U;RVAR=U;END;
00489                      OUTPUT;END;
00490 KEEP TYPE SERVICE PLANT RV IFL RV_F1 RV_F2 RV_FE1 RV_FE2 RV FF RV EI IFL
00491      F1 F2 FE1 FE2 TURN FE NTRIAL OPTION2 PERIOD OPTION3
00492      TOTAL PARTS LABOR CREDIT MONITOR VISUAL REPAIR N OCF URF;
00493 *;
00494 ************************************************************************;
00495 *  THE FOLLOWING CODE COMPUTES AND PRINTS THE ESTIMATED EMISSION      *;
00496 *  FACTORS AND PERCENT REDUCTION IN EMISSIONS (INCLUDING 90%          *;
00497 *  CONFIDENCE LIMITS) PER TURNAROUND.                                 *;
00498 ************************************************************************;
00499 *;
```


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Table B-1. (Continued)

```
00500 DATA GENERATE; SET GENERATE;
00501 IF (RV_IFL <0 OR RV_IFL >(2*IFL )) OR (RV_F1 <0 OR RV_F1 >(2*F1 )) OR
00502    (RV_F2  <0 OR RV_F2  >(2*F2  )) OR (RV_FE1<0 OR RV_FE1>(2*FE1)) OR
00503    (RV_FE2 <0 OR RV_FE2 >(2*FE2 )) THEN DELETE;
00504 ARRAY MU(I) IFL F1 F2 FE1 FE2;
00505 ARRAY RV(I) RV_IFL RV_F1 RV_F2 RV_FE1 RV_FE2;
00506 ARRAY U(Z)  FF  EI;   ARRAY RVAR(Z)  RV_FF  RV_EI;
00507 DO OVER MU; MU=RV; END;   DO OVER U; U=RVAR; END;
00508 _DEVELOP;
00509 PROC UNIVARIATE NOPRINT; BY PLANT TYPE SERVICE;
00510     VAR L1-L72 R1-R72 OR1-OR72;
00511     OUTPUT OUT=STATS P5=LOWL1-LOWL72 LOWR1-LOWR72 LOWOR1-LOWOR72
00512     P95=HIGHL1-HIGHL72 HIGHR1-HIGHR72 HIGHOR1-HIGHOR72;
00513 DATA EFMEANS;MERGE STATS INPUT(KEEP=TYPE PLANT SERVICE  TURN
00514                                 OPTION1 PERIOD OPTION2 FF IFL)
00515              RAW (KEEP=TYPE PLANT SERVICE L1-L72 R1-R72 OR1-OR72);
00516   BY PLANT TYPE SERVICE;
00517 ARRAY _EF(K) EF1-EF24;
00518 ARRAY _EFL(K) EFL1-EFL24;  ARRAY _EFU(K) EFU1-EFU24;
00519 ARRAY _R(K) R01-R024;
00520 ARRAY _RL(K) RL1-RL24;  ARRAY _RU(K) RU1-RU24;
00521 ARRAY _OR(K) RE01-RE024;
00522 ARRAY _ORL(K) REDL1-REDL24;  ARRAY _ORU(K) REDH1-REDH24;
00523 ARRAY _ML (T) L1-L72;
00524 ARRAY  MLL(T) LOWL1-LOWL72;  ARRAY _MLU(T) HIGHL1-HIGHL72;
00525 ARRAY  MR(T) R1-R72;
00526 ARRAY _MRL(T) LOWR1-LOWR72;  ARRAY _MRU(T) HIGHR1-HIGHR72;
00527 ARRAY _MOR(T) OR1-OR72;
00528 ARRAY _MORL(T) LOWOR1-LOWOR72;  ARRAY _MORU(T) HIGHOR1-HIGHOR72;
00529 DO OVER _MLL;
00530 _MLL=(_ML- MLL)**2; _MLU=(_MLU-_ML)**2;
00531 _MRL=(_MR- _MRL)**2; _MRU=(_MRU-_MR)**2;
00532 _MORL=(_MOR-_MORL)**2;  _MORU=(_MORU-_MOR)**2;
00533 END;
00534 ARRAY _SUM SUM1-SUM9;DO OVER _SUM;  SUM=0;END;
00535 I=0;K=0;
00536 TN=TURN/PERIOD;
00537 N=72/PERIOD;
00538 DO  I=1 TO N;
00539 SUM1=SUM(SUM1,_ML);SUM2=SUM(SUM2,_MLL);SUM3=SUM(SUM3,_MLU);
00540 SUM4=SUM(SUM4,_MR);SUM5=SUM(SUM5,_MRL);SUM6=SUM(SUM6,_MRU);
00541 SUM7=SUM(SUM7,_MOR);SUM8=SUM(SUM8,_MORL);SUM9=SUM(SUM9,_MORU);
00542 I=I+1;
00543 IF I=TN THEN DO; K=K+1;
00544  EF=SUM1/TN; EFL= EF-SQRT(SUM2/TN); EFU= EF+SQRT(SUM3/TN);
00545 _R=SUM4/TN;  RL= R-SQRT(SUM5/TN);  RU= R+SQRT(SUM6/TN);
00546 _OR=SUM7/TN;  ORL= OR-SQRT(SUM8/TN);  ORU= OR+SQRT(SUM9/TN);
00547 I=0;:DO OVER _SUM;  _SUM=0;END;
00548 END;
00549 END;
```

Table B-1. (Continued)

```
00550 KEEP TYPE PLANT SERVICE K EF1-EF24 EFL1-EFL24 EFU1-EFU24
00551       RD1-RD24 RL1-RL24 RU1-RU24 RED1-RED24 REDL1-REDL24 REDH1-REDH24
00552       OPTION1;
00553 DATA  NULL ;SET EFMEANS;BY PLANT TYPE SERVICE;
00554 FILE PRINT N=PS LL=LL HEADER=H NOTITLES;
00555 M=-1;
00556 ARRAY _EF (J) EF1-EF24;  ARRAY _EFL(J) EFL1-EFL24;
00557 ARRAY _EFU (J) EFU1-EFU24;
00558 ARRAY _R (J) RD1-RD24; ARRAY _RL (J) RL1-RL24; ARRAY _RU (J) RU1-RU24;
00559 ARRAY _R2(J) RED1-RED24;  ARRAY _R2L (J) REDL1-REDL24;
00560 ARRAY _R2U (J) REDH1-REDH24;
00561 DO OVER  R;  _R=100* R;  _R2=100*_R2;
00562    IF OPTION1=1 THEN DO;  _RL=100* RL;  _RU=100* RU;
00563    _R2L=100* R2L;  _R2U=100* R2U;  END;
00564 END;
00565 NEF=K;
00566 IF OPTION1=1 THEN DO; C1=62; C2=18; END;
00567 ELSE IF OPTION1=0 THEN DO; C1=67; C2=22; END;
00568 IF FIRST.SERVICE THEN LINK PAGE;
00569 DO J=1 TO NEF;
00570 IF LL<5 THEN LINK PAGE;
00571 IF OPTION1=1 THEN PUT @8 J 2. @22 _EF 6.4 +2 '(' _EFL 5.3 ,  _EFU 5.3
00572       ')' @54 _R 5.1 +2 '(' _RL 3. ,  RU 2. ')' @77 _R2 5.1 +2 '('
00573       R2L 3. ,  R2U 2. ')' /  ;
00574 ELSE IF OPTION1=0 THEN PUT @8 J 2. @28 _EF 6.4 @59  R 5.1 @80  R2 5.1 /;
00575 END;
00576 RETURN;
00577 PAGE:  PUT _PAGE ;
00578 PUT @C1 'PERCENT REDUCTION  @; IF OPTION1=1 THEN PUT +1  (90% CI)' @;
00579 PUT / @54 43* '-' / @75 'COMPARED TO EMISSION  / @4 'TURNAROUND
00580    @56 'COMPARED TO' @73 'FOR WHICH NO MAINTENANCE  / @6  PERIOD
00581    @C2 'MEAN EMISSION-KG/HR' @; IF OPTION1=1 THEN PUT +1  (90% CI)  @;
00582 PUT @54 'INITIAL EMISSION  @74 'WAS DONE DURING PERIOD  / @4 93* '-  //;
00583 RETURN;
00584 H:  PUT ///// @19 'SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND '
00585     'PERCENT REDUCTION  / @13 'IN MASS EMISSIONS FOR  'TYPE +1 /
00586     SERVICE 'SERVICE  +1  'BY TURNAROUND -  'PLANT  +1 PLANT ////  :
00587 RETURN;
00588 *;
00589 ************************************************************************;
00590 *   THE FOLLOWING CODE PRINTS OUT THE FRACTION OF TOTAL SOURCES        *;
00591 *   SCREENED AND OPERATED ON FOR EACH MONTH OF THE SIX YEAR            *;
00592 *   MAINTENANCE PROGRAM.                                              *;
00593 ************************************************************************;
00594 *;
00595 DATA  NULL ; SET RAW; BY PLANT TYPE SERVICE;
00596 FILE PRINT LL=L HEADER=H NOTITLES;
00597 IF OPTION2=0 THEN RETURN;
00598 M=-1;
00599 ARRAY  FS1 (J) FS1-FS12; ARRAY  FM1 (J) FM1-FM12;
```

Table B-1. (Continued)

```
00600 ARRAY  FS2 (J) FS13-FS24; ARRAY  FM2 (J) FM13-FM24;
00601 ARRAY  FS3 (J) FS25-FS36; ARRAY  FM3 (J) FM25-FM36;
00602 ARRAY  FS4 (J) FS37-FS48; ARRAY  FM4 (J) FM37-FM48;
00603 ARRAY  FS5 (J) FS49-FS60; ARRAY  FM5 (J) FM49-FM60;
00604 ARRAY  FS6 (J) FS61-FS72; ARRAY  FM6 (J) FM61-FM72;
00605 FORMAT FS1-FS72 FM1-FM72 IFM IFS 6.4;
00606 IF FIRST.SERVICE THEN PUT  PAGE ;
00607 PUT @1  INITIAL  @12 IFS @21 IFM @35  --  @44  --  @56  --  @65  --
00608    @77  --  @86  --  @98  --  @107  --  @119  --  @128  --  /  :
00609 DO J=1 TO 12;
00610 PUT @3 J 2. @12  FS1 @21  FM1 @33  FS2 @42  FM2 @54  FS3 @63  FM3
00611     @75  FS4 @84  FM4 @96  FS5 @105  FM5 @117  FS6 @126  FM6 /  :
00612 END;
00613 RETURN;
00614 H:  PUT /// @20  FRACTION OF TOTAL SOURCES SCREENED AND OPERATED ON FOR
00615     +1 TYPE +M  // SERVICE  SERVICE  / @50  BY MONTH - PLANT  PLANT
00616     ///// @15  1ST YEAR  @36  2ND YEAR  @57  3RD YEAR  @78  4TH YEAR
00617     @99  5TH YEAR  @120  6TH YEAR  / @11 17* -  @32 17* -  @53 17* -
00618     @74 17* -  @95 17* -  @116 17* -  / @20  FRACTION  @41  FRACTION
00619     @62  FRACTION  @83  FRACTION  @104  FRACTION  @125  FRACTION  /
00620     @11  FRACTION OPERATED  @32  FRACTION OPERATED
00621     @53  FRACTION OPERATED  @74  FRACTION OPERATED
00622     @95  FRACTION OPERATED  @116  FRACTION OPERATED  / @2  MONTH
00623     @11  SCREENED  @23  ON  @32  SCREENED  @44  ON  @53  SCREENED
00624     @65  ON  @74  SCREENED  @86  ON  @95  SCREENED  @107  ON
00625     @116  SCREENED  @128  ON  /@1 7* -  @11 8* -  @20 8* -  @32 8* -
00626     @41 8* -  @53 8* -  @62 8* -  @74 8* -  @83 8* -  @95 8* -
00627     @104 8* -  @116 8* -  @125 8* -    ;
00628 RETURN;
00629 *;
00630 ************************************************************************;
00631 *   THE FOLLOWING CODE PRINTS OUT THE ESTIMATED EMISSION FACTORS      *;
00632 *   AND PERCENT REDUCTION IN EMISSIONS (INCLUDING 90% CON-            *;
00633 *   FIDENCE LIMITS) FOR EACH PERIOD OF THE SIX YEAR MAINTENANCE       *;
00634 *   PROGRAM.                                                          *;
00635 ************************************************************************;
00636 *;
00637 DATA  NULL ; MERGE STATS INPUT(KEEP=TYPE PLANT SERVICE PERIOD
00638                                 OPTION1 OPTION2 FF IFL)
00639           RAW (KEEP=TYPE PLANT SERVICE L1-L72 R1-R72 OR1-OR72);
00640  BY PLANT TYPE SERVICE;
00641 FILE PRINT N=PS LL=LL HEADER=H NOTITLES;
00642 IF OPTION2=0 THEN RETURN;
00643 M=-1;
00644 ARRAY  ML (J) L1-L72;  ARRAY  LOWL (J) LOWL1-LOWL72;
00645 ARRAY  HIGHL (J) HIGHL1-HIGHL72;  ARRAY  MR (J) R1-R72;
00646 ARRAY  LOWR (J) LOWR1-LOWR72;  ARRAY  HIGHR (J) HIGHR1-HIGHR72;
00647 ARRAY  MR2 (J) OR1-OR72;  ARRAY  LOWR2 (J) LOWOR1-LOWOR72;
00648 ARRAY  HIGHR2 (J) HIGHOR1-HIGHOR72;
00649 DO OVER  MR;   MR=100* MR;   MR2=100* MR2;
```


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Table B-1. (Continued)

```
00650    IF OPTION1=1 THEN DO; _LOWR=100*_LOWR;   HIGHR=100*_HIGHR;
00651     _LOWR2=100*_LOWR2;  _HIGHR2=100*_HIGHR2;  END;
00652 END;
00653 IF OPTION1=1 THEN DO; C1=62; C2=18; END;
00654 ELSE IF OPTION1=0 THEN DO; C1=67; C2=22; END;
00655 IF FIRST.SERVICE THEN LINK PAGE;
00656 L=72/PERIOD;
00657 DO J=1 TO L;
00658 IF LL<5 THEN LINK PAGE;
00659 IF OPTION1=1 THEN PUT @6 J 2. @22 _ML 6.4 +2 '(' _LOWL 5.3 '-'
00660     HIGHL 5.3 ')' @54 _MR 5.1 +2 '(' _LOWR 5. '-' _HIGHR 2. ')' @77
00661     MR2 5.1 +2 '(' _LOWR2 5. '-' _HIGHR2 2. ')' :
00662 ELSE IF OPTION1=0 THEN PUT @8 J 2. @28 ML 6.4 @59 _MR 5.1 @80 MR2 5.1;
00663 END;
00664 RETURN;
00665 PAGE:  PUT _PAGE ;
00666 PUT @C1 'PERCENT REDUCTION' @:  IF OPTION1=1 THEN PUT +1 '(90% CI)' @:
00667 PUT / @54 43*'-' / @75 'COMPARED TO EMISSION' / @6 'PERIOD' @56
00668     'COMPARED TO' @73 'FOR WHICH NO MAINTENANCE' / @4 '(' 'PERIOD'
00669     'MONTHS)' @C2 'MEAN EMISSION-KG/HR' @:
00670    IF OPTION1=1 THEN PUT +1 '(90% CI)' @ :
00671 PUT @54 'INITIAL EMISSION' @74 'WAS DONE DURING PERIOD' / @4 93*'-' / :
00672 RETURN;
00673 H:  PUT ///  @24 'ESTIMATED EMISSION FACTORS (KG/HR) AND PERCENT'
00674     'REDUCTION' / @17 'IN MASS EMISSIONS FOR' TYPE +M '/' SERVICE
00675     'SERVICE BY PERIOD - PLANT' PLANT ///  ;
00676 RETURN;
00677 *;
00678 ************************************************************************;
00679 *  THE FOLLOWING CODE PRINTS OUT THE FRACTIONAL DISTRIBUTION OF       *;
00680 *  SOURCES FOR THE BEGINNING (IMMEDIATELY FOLLOWING PERIODIC          *;
00681 *  MAINTENANCE) AND FOR THE END (JUST BEFORE PERIODIC MAINTENANCE     *;
00682 *  IS PERFORMED) OF EACH PERIOD.                                      *;
00683 ************************************************************************;
00684 *;
00685 DATA _NULL_; SET RAW; BY PLANT TYPE SERVICE;
00686 FILE PRINT LL=LL HEADER=H NOTITLES;
00687 IF OPTION2=0 THEN RETURN;
00688 M=-1;
00689 ARRAY _FL2 (J) FL2_0-FL2_71;  ARRAY _FL1 (J) FL1_1-FL1_72;
00690 ARRAY _FE12 (J) FE12_0-FE12_71;  ARRAY _FE11 (J) FE11_1-FE11_72;
00691 ARRAY _FE22 (J) FE22_0-FE22_71;  ARRAY _FE21 (J) FE21_1-FE21_72;
00692 ARRAY _FP2 (J) FP2_0-FP2_71;  ARRAY _FP1 (J) FP1_1-FP1_72;
00693 IF FIRST.SERVICE THEN PUT _PAGE ;
00694 PUT @3 'INITIAL' @19 FL1_0 5.3 @38 '---' @48 FE11_0 5.3 @62 '---'
00695     @73 FE21_0 6.4 @88 '---' @96 FP1_0 5.3 :
00696 L=72/PERIOD;
00697 DO J=1 TO L;
00698 IF LL<5 THEN PUT _PAGE ;
00699 PUT @5 J 2. @19 FL1 5.3 @37 FE12 5.3 @48 FE11 5.3 @61 FE22 6.4
```

Table B-1. (Continued)

```
00700      @73  FE21 6.4 @87  FP2 5.3 @98  FP1 5.3  ;
00701 END;
00702 IF FIRST.SERVICE THEN PUT /// @7 '* LEAKERS REFERS TO THOSE '
00703       'SOURCES SCREENING GREATER THAN OR EQUAL TO THE ACTION LEVEL.'  /@7
00704     '(1)  JUST BEFORE PERIODIC MAINTENANCE IS PERFORMED.'  /@7
00705     '(2)  IMMEDIATELY FOLLOWING PERIODIC MAINTENANCE.'  ;
00706 RETURN;
00707 H:  PUT //   @23  'FRACTIONAL DISTRIBUTION OF SOURCES FOR' +1 TYPE
00708      +M  /  SERVICE 'SERVICE' / @38  'BY PERIOD - PLANT'  PLANT  ////
00709      @40  'FRACTION OF'  @60  'FRACTION OF'
00710      'SOURCES' @80  'FRACTION OF SOURCES'  / @16  'FRACTION OF'
00711      @36  'UNREPAIRED SOURCES' @57  'EXPERIENCING EARLY FAILURE
00712      @80  'OPERATING PROPERLY'  / @16  'LEAKERS* DUE'  @35  20* -  @57  20* -
00713      @80  20* -  / @3  'PERIOD'  @15  'TO OCCURRENCE'  @35  'BEGINNING(2)'
00714      @49  'END'  @59  'BEGINNING'  @74  'END'  @85  'BEGINNING'  @99  'END' /
00715      @1  '('  PERIOD 'MONTHS)'  @14  'AT END OF PERIOD(1)'  @35  'OF PERIOD' +2
00716      'OF PERIOD'  @59  'OF PERIOD'  OF PERIOD'  @85  'OF PERIOD'  OF PERIOD'
00717      /  @1  105* -'    ;
00718 RETURN;
00719 *;
00720 ************************************************************************;
00721 *  THE FOLLOWING CODE PRINTS OUT A PLANT SUMMARY                        *;
00722 *  OF INITIAL LEAK REPAIR COSTS                                         *;
00723 ************************************************************************;
00724 *;
00725 DATA _NULL_ ; SET FSFM; BY PLANT TYPE SERVICE;
00726 FILE PRINT HEADER=H NOTITLES;
00727 M=-1;
00728 ARRAY _ALL (ST) IFM LEAKS IFC ILC IDC TIRC AC;
00729 ARRAY _RND (ST) RND1-RND7;
00730 DO OVER _RND;
00731    IF ._ALL<0 THEN DO;  _ALL=ABS(_ALL);  NEG=-1;  END;
00732    ELSE NEG=1;
00733    IF _ALL>0 THEN DO;
00734     RND=10**(FLOOR(LOG10(_ALL))-2);
00735    _ALL=NEG*ROUND(_ALL,_RND);
00736    END;
00737 END;
00738 IF FIRST.PLANT THEN DO;  PUT _PAGE_ ;  S=1 ;  END;
00739 IF FIRST.TYPE THEN PUT //  TYPE;
00740 PUT / +2 SERVICE @:
00741 IF TOTAL=. THEN PUT @25
00742     '*****  COST DATA IS NOT AVAILABLE TO THIS PROGRAM  *****';
00743 ELSE PUT @19 IFM 5.3 +2 TOTAL COMMA7. +2 LEAKS COMMA6. +4 S +M
00744          IFC COMMA9. +3 S +M ILC COMMA9. +3 S +M IDC COMMA9.
00745          +3 S +M TIRC COMMA9. +4 S +M AC COMMA7.  ;
00746 RETURN;
00747 H:  PUT /// +41  PLANT  +1 PLANT  SUMMARY:'  //
00748     +40  'INITIAL LEAK REPAIR COSTS'  //// +35  'NUMBER'  +15
00749     'INITIAL LEAK REPAIR COSTS'  / +16  'INITIAL'  +2  'NUMBER'
```

Table B-1. (Continued)

```
00750      +6 'OF' +5 49*'-' / +18 'LEAK' +5 'OF' +6 'INITIAL' +30
00751      'ADMIN &' +16 'ANNUALIZED' / +2 'SOURCE TYPE' +5 'FREQ'
00752      +3 'SOURCES' +4 'LEAKS' +7 'PARTS' +8 'LABOR' +6 'SUPPORT'
00753      +7 'TOTAL' +6 'CHARGES' / 105*'-' @ ;
00754 RETURN;
00755 *;
00756 ************************************************************************;
00757 *  THE FOLLOWING CODE PRINTS OUT THE MO'TORING AND REPAIR COST        +;
00758 *  BREAKDOWN FOR SOURCES BY YEAR.                                     +;
00759 ************************************************************************;
00760 *;
00761 PROC FORMAT DDNAME=SASLIB;
00762   VALUE P 1='  (MONTHLY'  3='(QUARTERLY'  6='(BI-YEARLY'
00763           9='  (9-MONTH  12='   (YEARLY';
00764 DATA _NULL_; SET FSFM; BY PLANT TYPE SERVICE;
00765 FILE PRINT HEADER=H NOTITLES;
00766 IF OPTION2=0 THEN RETURN;
00767 M=-1;
00768 ARRAY _ALL (Z) MC1-MC6 PC1-PC6 LC1-LC6 OC1-OC6 AC TC1-TC6 TMC
00769                TPC TLC TOC TAC TTC AVG1-AVG5;
00770 ARRAY _RND (Z) RND1-RND42;
00771 DO OVER _RND;
00772    IF .<_ALL<0 THEN DO;  _ALL=ABS(_ALL);  NEG=-1;  END;
00773    ELSE NEG=1;
00774    IF _ALL>0 THEN DO;
00775    _RND=10**(FLOOR(LOG10(_ALL))-2);
00776     ALL=NEG*ROUND(_ALL,_RND);
00777    END;
00778 END;
00779 ARRAY _MC (J) MC1-MC6;  ARRAY _LC (J) LC1-LC6;
00780 ARRAY _PC (J) PC1-PC6;  ARRAY _OC (J) OC1-OC6;
00781 ARRAY _TC (J) TC1-TC6;
00782 IF FIRST.SERVICE THEN PUT _PAGE_;
00783 IF TOTAL=. THEN PUT ////// @25
00784    '***** COST DATA IS NOT AVAILABLE TO THIS PROGRAM *****' :
00785 ELSE DO;
00786 DO J=1 TO 6;
00787 IF J=1 THEN S='$'; ELSE S=' ';
00788 PUT / +9 J 1. +8 S +M _MC COMMA9. +5 S +M _LC COMMA9. +4 S +M
00789      _PC COMMA9. +5 S +M _OC COMMA9. +5 S +M AC COMMA7. +6 S +M
00790      _TC COMMA9.  /  ;
00791 END;
00792 PUT +18 10*'-' +5 10*'-' +4 10*'-' +5 10*'-' +5 8*'-' +6
00793     10*'-'  //  +7 'TOTAL' +6 '$' TMC COMMA9. +5 '$' TLC COMMA9.
00794     +4 '$' TPC COMMA9. +5 '$' TOC COMMA9. +5 '$' TAC
00795     COMMA7. +6 '$' TTC COMMA9.  ///
00796     +4 'ANNUAL AVG' +4 '$' AVG1 COMMA9. +5 '$' AVG3 COMMA9.
00797     +4 '$' AVG2 COMMA9. +5 '$' AVG4 COMMA9. +5 '$' AC COMMA7.
00798     +6 '$' AVG5 COMMA9. ;
00799 END;
```

Table B-1. (Continued)

```
00800 RETURN;
00801 H:  PUT ///   +30 'MONITORING AND LEAK REPAIR COSTS - PLANT '
00802     PLANT / +32 PERIOD P10. ' LDAR FOR ' SERVICE TYPE +M ')'
00803     //// +76 'ANNUALIZED' / +18 'MONITORING' +7 'ONGOING '
00804     'REPAIR COSTS' +8 'ADMIN AND' +4 'CHARGE FOR' / +21 'LABOR'
00805     +7 24*'-' +7 'SUPPORT' +7 'INITIAL' +9 'GROSS' /
00806     +7 'YEAR' +10 'COSTS' +10 'LABOR' +9 'PARTS' +10 'COSTS'
00807     +6 'LEAK REPAIR' +7 'COST' / +4 97*'-'  ;
00808 RETURN;
00809 *;
00810 ************************************************************************;
00811 *  THE FOLLOWING CODE PRINTS OUT THE AVERAGE ANNUAL MONITORING         *;
00812 *  AND LEAK REPAIR COSTS FOR EACH PLANT                                *;
00813 ************************************************************************;
00814 *;
00815 DATA _NULL_; SET FSFM; BY PLANT TYPE SERVICE;
00816 FILE PRINT HEADER=H NOTITLES;
00817 M=-1;
00818 ARRAY _AVG (P) AVG1-AVG5 AC;
00819 ARRAY _TOTAL (P) TOTAL1-TOTAL5 TOTALAC;
00820 RETAIN TOTAL1-TOTAL5 TOTALAC;
00821 DO OVER _TOTAL; IF FIRST.PLANT THEN _TOTAL=0; _TOTAL+_AVG;  END;
00822 ARRAY _ALL (Z) AVG1-AVG5 AC TOTAL1-TOTAL5 TOTALAC;
00823 ARRAY _NEW (Z) NAVG1-NAVG5 NAC NTOTAL1-NTOTAL5 NTOTAL;
00824 ARRAY _RND (Z) RND1-RND12;
00825 DO OVER _RND;
00826    IF .< _ALL<0 THEN DO;  _ALL=ABS(_ALL);  NEG=-1;  END;
00827    ELSE NEG=1;
00828    IF _ALL>0 THEN DO;
00829    _RND=10**(FLOOR(LOG10(_ALL))-2);
00830    _NEW=NEG*ROUND(_ALL,_RND);  _ALL=NEG*_ALL;
00831    END;  ELSE _NEW=_ALL;
00832 END;
00833 IF FIRST.PLANT THEN DO; PUT _PAGE_; S='$'; END;
00834 IF FIRST.TYPE THEN PUT // +2 TYPE;
00835 PUT / +4 SERVICE @;
00836 IF TOTAL=. THEN PUT @25
00837     '*****  COST DATA IS NOT AVAILABLE TO THIS PROGRAM  *****' ;
00838 ELSE PUT @21 S +M NAVG1 COMMA9. +5 S +M NAVG3 COMMA9. +4
00839     S +M NAVG2 COMMA9. +5 S +M NAVG4 COMMA9. +5 S +M NAC COMMA7.
00840     +6 S +M NAVG5 COMMA9.  ;
00841 IF LAST.PLANT THEN PUT / +20 10*'-' +5 10*'-' +4 10*'-' +5 10*'-' +5
00842     8*'-' +6 10*'-' // +2 'PLANT TOTAL' @21 '$' NTOTAL1 COMMA9.
00843     +5 '$' NTOTAL3 COMMA9. +4 '$' NTOTAL2 COMMA9. +5 '$'
00844     NTOTAL4 COMMA9. +5 '$' NTOTAL COMMA7. +6 '$' NTOTAL5 COMMA9.;
00845 RETURN;
00846 H:  PUT /// +44 'PLANT ' PLANT 'SUMMARY:'  //
00847     +29 'AVERAGE ANNUAL MONITORING AND LEAK REPAIR COSTS' /
00848     +44 PERIOD P10. +1 'LDAR)' ////  +78 'ANNUALIZED' / +20
00849     'MONITORING' +7 'ONGOING REPAIR COSTS' +8 'ADMIN AND' +4
```


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Table B-1. (Continued)

```
00850      'CHARGE FOR' / +23 'LABOR' +7 24*'-' +7 'SUPPORT' +7 'INITIAL
00851      +9 'GROSS' / +3 'SOURCE TYPE' +9 'COSTS' +10 'LABOR' +9 'PARTS'
00852      +10 'COSTS' +6 'LEAK REPAIR' +7 'COST' / +2 101*'-' @ ;
00853 RETURN;
00854 *;
00855 ************************************************************************;
00856 *  THE FOLLOWING CODE PRINTS OUT THE COST EFFECTIVENESS                 *;
00857 *  ANALYSIS RESULTS FOR SOURCES BY YEAR.                                *;
00858 ************************************************************************;
00859 *;
00860 DATA COST; MERGE INPUT FSFM; BY PLANT TYPE SERVICE;
00861 FILE PRINT HEADER=H NOTITLES;
00862 M=-1;
00863 EL=EI/(IFL+(1-IFL)*F2); EF=F2*EL;
00864 ARRAY _EF (J) EF1-EF6;  ARRAY _ER (J) ER1-ER6;  ARRAY _RC (J) RC1-RC6;
00865 ARRAY _NC (J) NC1-NC6;
00866 ARRAY _GCE (J) GCE1-GCE6;  ARRAY _TC (J) TC1-TC6;
00867 ARRAY _NCE (J) NCE1-NCE6;  ARRAY _L (J) L1-L6;
00868 IF PERIOD=1 THEN DO;
00869   EF1=MEAN(OF L1-L12);  EF2=MEAN(OF L13-L24);  EF3=MEAN(OF L25-L36);
00870   EF4=MEAN(OF L37-L48);  EF5=MEAN(OF L49-L60);  EF6=MEAN(OF L61-L72);
00871 END;
00872 ELSE IF PERIOD=3 THEN DO;
00873   EF1=MEAN(OF L1-L4);  EF2=MEAN(OF L5-L8);  EF3=MEAN(OF L9-L12);
00874   EF4=MEAN(OF L13-L16);  EF5=MEAN(OF L17-L20);  EF6=MEAN(OF L21-L24);
00875 END;
00876 ELSE IF PERIOD=6 THEN DO;
00877   EF1=MEAN(L1,L2);  EF2=MEAN(L3,L4);  EF3=MEAN(L5,L6);
00878   EF4=MEAN(L7,L8);  EF5=MEAN(L9,L10);  EF6=MEAN(L11,L12);
00879 END;
00880 ELSE IF PERIOD=9 THEN DO;
00881   EF1=(0.75*L1)+(0.25*L2);  EF2=(0.5*L2)+(0.5*L3);
00882   EF3=(0.25*L3)+(0.75*L4);  EF4=(0.75*L5)+(0.25*L6);
00883   EF5=(0.5*L6)+(0.5*L7);    EF6=(0.25*L7)+(0.75*L8);
00884 END;
00885 ELSE IF PERIOD=12 THEN DO OVER _EF;  _EF= L;  END;
00886 DO OVER _ER;
00887    ER=TOTAL*(EI- EF)*8.76;
00888    RC= ER*CREDIT;
00889    NC= TC- RC;
00890    GCE= TC/ ER;
00891    NCE= NC/ ER;
00892 END;
00893   TTC=SUM(OF TC1-TC6);
00894   TER=SUM(OF ER1-ER6);
00895   TRC=SUM(OF RC1-RC6);
00896   TNC=SUM(OF NC1-NC6);
00897   TGCE=TTC/TER;
00898   TNCE=TNC/TER;
00899 ARRAY _AVG (IT) A1-A3;  ARRAY _SUM (IT) S1-S3;
```

Table B-1. (Continued)

```
00900 DO OVER _SUM;  _SUM=0;  END;
00901 DO J=NN1 TO NN2;
00902 S1=SUM(S1,_ER);  S2=SUM(S2,_RC);  S3=SUM(S3,_NC);
00903 END;
00904 DO OVER _AVG;  _AVG=_SUM/(NN2-NN1+1);  END;
00905 A4=SUM5/S1;  A5=S3/S1;
00906 ARRAY _ALL (Z) ER1-ER6 RC1-RC6 NC1-NC6 GCE1-GCE6 NCE1-NCE6
00907                TER TRC TNC TGCE TNCE;
00908 ARRAY _RND (Z) RND1-RND35;
00909 DO OVER _RND;
00910    IF .< _ALL<0 THEN DO;  _ALL=ABS(_ALL);  NEG=-1;  END;
00911    ELSE NEG=1;
00912    IF _ALL>0 THEN DO;
00913    _RND=10**(FLOOR(LOG10(_ALL))-2);
00914    _ALL=NEG*ROUND(_ALL,_RND);
00915    END;
00916 END;
00917 ARRAY _ALL2 (ZZ) A1-A5;  ARRAY _RD (ZZ) RD1-RD5;
00918 ARRAY _TP (ZZ) TP1-TP5;
00919 DO OVER _RD;
00920    IF .< _ALL2<0 THEN DO;  _ALL2=ABS(_ALL2);  NEG=-1;  END;
00921    ELSE NEG=1;
00922    IF _ALL2>0 THEN DO;
00923    _RD=10**(FLOOR(LOG10(_ALL2))-2);
00924    _TP=NEG*ROUND(_ALL2,_RD);  _ALL2=NEG*_ALL2;
00925    END;  ELSE _TP=_ALL2;
00926 END;
00927 IF OPTION2=0 THEN RETURN;
00928 IF FIRST.SERVICE THEN DO; PUT _PAGE_;
00929    IF TOTAL=. THEN DO; PUT ////// @25
00930       '*****  COST DATA IS NOT AVAILABLE TO THIS PROGRAM  *****' ;
00931 RETURN;  END;  END;
00932 DO J=1 TO 6;
00933 IF J=1 THEN S='$'; ELSE S=' ';
00934 PUT / @13 J 1. @23 _ER BEST7. @38 S +M  RC COMMA9. @54 S +M _NC
00935     COMMA9. @71 S +M _GCE COMMA6. @87 S +M _NCE COMMA6. /  ;
00936 END;
00937 PUT @23 7*'-' @38 10*'-' @54 10*'-' @71 7*'-' @87 7*'-' //
00938     @11 'TOTAL' @23 TER BEST7. @38 '$' TRC COMMA9. @54 '$'
00939     TNC COMMA9. @71 '$' TGCE COMMA6. @87 '$' TNCE COMMA6.  ///
00940     +7 'ANNUAL AVG' @23 TP1 BEST7. @38 '$' TP2 COMMA9. @54 '$'
00941     TP3 COMMA9. @71 '$' TP4 COMMA6. @87 '$' TP5 COMMA6. ;
00942 RETURN;
00943 H:  PUT ///  +38 'COST EFFECTIVENESS - PLANT  ' PLANT / +32
00944     PERIOD F10. +1 'LDAR FOR ' SERVICE TYPE +M ' ' ////
00945     @23 'EMISSION' @70 'GROSS COST' @87 'NET COST' / @23 'REDUCTION'
00946     @39 'RECOVERY' @58 'NET' @69 'EFFECTIVENESS' @85 'EFFECTIVENESS' /
00947     @11 'YEAR' @24 '(MG/YR)' @40 'CREDIT' @57 'COSTS' @71 '(PER MG)'
00948     @87 '(PER MG)' / @8 90*'-'  ;
00949 RETURN;
```

Table B-1. (Continued)

```
00950 *;
00951 ************************************************************************;
00952 *  THE FOLLOWING CODE PRINTS OUT THE AVERAGE ANNUAL COST                 *;
00953 *  EFFECTIVENESS FOR EACH PLANT                                          *;
00954 ************************************************************************;
00955 *;
00956 DATA _NULL_; SET COST; BY PLANT TYPE SERVICE;
00957 FILE PRINT HEADER=H NOTITLES;
00958 M=-1;
00959 ARRAY _AVG (F) A1-A5;  ARRAY _NEW (F) NT1-NT5;
00960 ARRAY _TOTAL (F) TOT1-TOT5;  ARRAY _RND (F) RND1-RND5;
00961 RETAIN TOT1-TOT5;
00962 DO OVER  TOTAL; IF FIRST.PLANT THEN _TOTAL=0; _TOTAL+_AVG;  END;
00963 IF FIRST.PLANT THEN GC=0;
00964 GC+AVG5; TOT5=TOT3/TOT1; TOT4=GC/TOT1;
00965 DO OVER _RND;
00966    IF .<_TOTAL<0 THEN DO;  _TOTAL=ABS(_TOTAL);  NEG=-1;  END;
00967    ELSE NEG=1;
00968    IF _TOTAL>0 THEN DO;
00969    _RND=10**(FLOOR(LOG10(_TOTAL))-2);
00970    _NEW=NEG*ROUND(_TOTAL,_RND);  _TOTAL=NEG*_TOTAL;
00971    END;  ELSE _NEW=_TOTAL;
00972 END;
00973 IF FIRST.PLANT THEN DO; PUT _PAGE_; S='$'; END;
00974 IF FIRST.TYPE THEN PUT // +5 TYPE;
00975 PUT / +7 SERVICE @;
00976 IF TOTAL=. THEN PUT @25
00977    '*****  COST DATA IS NOT AVAILABLE TO THIS PROGRAM  *****';
00978 ELSE PUT @25  TP1 BEST7. @40 S +M TP2 COMMA9. @56 S +M TP3
00979          COMMA9. @73 S +M TP4 COMMA6. @89 S +M TP5 COMMA6. ;
00980 IF LAST.PLANT THEN PUT / @25 7*'-' @40 10*'-' @56 10*'-' @73
00981                  7*'-' @89 7*'-' // +5 'PLANT TOTAL' @25
00982                  NT1 BEST7. @40 '$' NT2 COMMA9. @56 '$' NT3
00983                  COMMA9. @73 '$' NT4 COMMA6. @89 '$' NT5 COMMA6. ;
00984 RETURN;
00985 H:  PUT /// +44 'PLANT' +1 PLANT 'SUMMARY:' //
00986     +36 'AVERAGE ANNUAL COST EFFECTIVENESS' / +44 PERIOD P10. +1
00987     'LDAR)'  ////  @25 'EMISSION' @72 'GROSS COST' @89 'NET COST' /
00988     @25 'REDUCTION' @41 'RECOVERY' @60 'NET' @71 'EFFECTIVENESS'
00989     @87 'EFFECTIVENESS' / @7 'SOURCE TYPE' @26 '(MG/YR)'
00990     @42 'CREDIT' @59 'COSTS' @73 '(PER MG)' @89 '(PER MG)'  /
00991     @6 94*'-'  @ ;
00992 RETURN;
```

Table B-2. PDS Member: SETUP

```
00001 DATA CORRECT;
00002 INFILE SYSTERM MISSOVER;
00003 FILE TERM;
00004 LENGTH X1-X20 $50 X21-X29 $60 X30-X32 PLANT TYPE SERVICE ID $20
00005        ANS $1;
00006 DATARMT=SYSPARM(); STATUS=SCAN(DATARMT,3,'/');
00007 IF _N_=1 & STATUS NE 'NEW' THEN DO;
00008   PUT / 'DOES YOUR INPUT DATA FILE PRESENTLY CONTAIN CASES ' /
00009         'WHICH YOU WISH TO SAVE?' ;
00010   INPUT ANS $ ;
00011   IF ANS='N' THEN DO; END=1; EOFLAG=1; GO TO LABEL; END;
00012 END;
00013 IF _N_=1 & STATUS='NEW' THEN DO; END=1; EOFLAG=1; GO TO LABEL; END;
00014 RETAIN EOFLAG; IF EOFLAG THEN GO TO EOF;
00015 INFILE OLD END=EOF;
00016 INPUT TYPE=$20. SERVICE=$20. PLANT=$20. IFL= SE1= F1= SE2=
00017       F2= SE3= FE1= SE4= FE2= SE5= FF= FFA= FFB=
00018       EI= EIA= EIB= TURN= FE= OPTION1= OPTION2= OPTION3=
00019       PERIOD= TOTAL= MONITOR= VISUAL= REPAIR= PARTS= LABOR=
00020       CREDIT= OCF= CRF= N=  ;
00021 EOFLAG=EOF;
00022 INFILE SYSTERM MISSOVER;
00023 FILE TERM;
00024 RETAIN X1 'MONITORING INTERVAL (MONTHS)'
00025        X2 'TURNAROUND FREQUENCY (MONTHS)'
00026        X3 'EMISSION FACTOR (KG/HR/SOURCE)'
00027        X4 'LEAK OCCURRENCE RATE (% PER PERIOD)'
00028        X5 'INITIAL % LEAKING'
00029        X6 'EMISSIONS REDUCTION FOR UNSUCCESSFUL REPAIR (%)'
00030        X7 'EMISSIONS REDUCTION FOR SUCCESSFUL REPAIR (%)'
00031        X8 'EARLY LEAK RECURRENCE (% OF REPAIRS)'
00032        X9 'UNSUCCESSFUL REPAIR RATE (%)'
00033        X10 'UNSUCCESSFUL REPAIR RATE (%) AT TURNAROUND'
00034        X11 'TOTAL # OF SOURCES'
00035        X12 'MONITORING TIME PER SOURCE INSPECTION (MINUTES)'
00036        X13 'VISUAL MONITORING TIME PER SOURCE (MINUTES)'
00037        X14 'NUMBER OF VISUAL INSPECTIONS PER YEAR'
00038        X15 'REPAIR TIME PER SOURCE (MINUTES)'
00039        X16 'LABOR RATE ($/HOUR)'
00040        X17 'PARTS COST PER SOURCE ($)'
00041        X18 'A & S OVERHEAD COST FACTOR (%)'
00042        X19 'CAPITAL RECOVERY FACTOR (%)'
00043        X20 'RECOVERY CREDIT FOR EMISSIONS REDUCTION ($/MG)'
00044        X21 'STD ERROR OF INITIAL % LEAKING'
00045        X22 'STD ERROR OF EMISSION REDUCTION DUE TO UNSUCCESSFUL REPAIR'
00046        X23 'STD ERROR OF EMISSION REDUCTION DUE TO SUCCESSFUL REPAIR'
00047        X24 'STD ERROR OF UNSUCCESSFUL REPAIR RATE'
00048        X25 'STD ERROR OF EARLY LEAK RECURRENCE'
```


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Table B-2 (Continued)

```
00049         X26 'LOWER 95% CONFIDENCE LIMIT ON LEAK OCCURRENCE RATE'
00050         X27 'UPPER 95% CONFIDENCE LIMIT ON LEAK OCCURRENCE RATE'
00051         X28 'LOWER 95% CONFIDENCE LIMIT ON INITIAL EMISSION FACTOR'
00052         X29 'UPPER 95% CONFIDENCE LIMIT ON INITIAL EMISSION FACTOR'
00053         X30 'MODEL PLANT ID'
00054         X31 'SOURCE TYPE'
00055         X32 'SERVICE TYPE' ;
00056 ARRAY _X (I) X1-X20;  ARRAY _XSE (K) X21-X29;
00057 ARRAY _XX (S) X30-X32;
00058 ARRAY _VAR (I) PERIOD TURN EI FF IFL F1 F2 FE2 FE1 FE TOTAL MONITOR
00059                 VISUAL N REPAIR LABOR PARTS OCF CRF CREDIT;
00060 ARRAY _SE (K) SE1-SE5 FFA FFB EIA EIB;
00061 ARRAY _ID (S) PLANT TYPE SERVICE;
00062 IF PLANT=' ' & TYPE=' ' & SERVICE=' ' THEN DO;
00063   END=1; GO TO LABEL;
00064 END;
00065 PUT / 'MODEL PLANT' +1 PLANT '-' +1 SERVICE TYPE;
00066 Q1:  PUT / 'IS THIS A CHANGE, A DELETION, OR IS IT OK?';
00067       INPUT ANS $;
00068       IF ANS='O' THEN RETURN; ELSE IF ANS='D' THEN DELETE;
00069       ELSE IF ANS NE 'O' & ANS NE 'D' & ANS NE 'C' THEN DO;
00070         PUT / 'INCORRECT RESPONSE,' / 'TRY AGAIN WITH ONE '
00071         'OF THE FOLLOWING RESPONSES:  CHANGE  DELETION  OK';
00072         GO TO Q1;
00073       END;
00074 LABEL:  IF END THEN PUT / 'RESPOND TO EACH PARAMETER DESCRIPTION '
00075         'WITH THE INPUT VALUE.' /;
00076         ELSE
00077         PUT / 'IF A CHANGE IS REQUIRED RESPOND WITH THE CORRECTED '
00078         'VALUE,' / 'OTHERWISE PRESS RETURN.' /;
00079         DO OVER _ID;
00080           PUT _XX @25 _ID;
00081           INPUT ID &$; IF ID NE ' ' THEN _ID=ID;
00082         END;
00083         IF END THEN DO OVER _VAR;
00084           PUT _X; INPUT VALUE; _VAR=VALUE;
00085         END;
00086         ELSE DO OVER _VAR;
00087           PUT _X @59 _VAR;
00088           INPUT VALUE; IF VALUE NE . THEN _VAR=VALUE;
00089         END;
00090         IF PERIOD>1 THEN DO;
00091           PUT / 'ARE MONTHLY FOLLOW-UPS TO BE PERFORMED BETWEEN THE'
00092           / 'PERIODIC SCREENING AND MAINTENANCE OF SOURCES?' ;
00093           INPUT ANS $;
00094           IF ANS='Y' THEN OPTION3=1; ELSE IF ANS='N' THEN OPTION3=0;
00095         END;
00096         PUT / 'ARE CONFIDENCE INTERVALS ON EMISSION AND' /
```

Table B-2 (Continued)

```
00097          'REDUCTION ESTIMATES DESIRED?'  ;
00098          INPUT ANS $;
00099          IF ANS='Y' THEN OPTION1=1; ELSE IF ANS='N' THEN OPTION1=0;
00100          Q2:  IF OPTION1=1 THEN DO; IF END THEN GO TO Q3;
00101               PUT / 'IS THIS A CHANGE OR ARE THE '
00102               'CONFIDENCE INTERVAL INPUTS OK?';
00103               INPUT ANS $;
00104          Q3:  IF ANS='C' OR END THEN DO;
00105                 IF END THEN PUT /  'RESPOND TO EACH PARAMETER
00106                 'DESCRIPTION WITH THE INPUT VALUE.'  /;  ELSE
00107                 PUT / 'IF A CHANGE IS REQUIRED RESPOND WITH THE '
00108                 'CORRECTED VALUE,' / 'OTHERWISE PRESS RETURN.' / ;
00109                 IF END THEN DO OVER _SE;
00110                   PUT _XSE;  INPUT VALUE;  _SE=VALUE;
00111                 END;
00112                 ELSE DO OVER _SE;
00113                   PUT _XSE @65 _SE;
00114                   INPUT VALUE; IF VALUE NE . THEN _SE=VALUE;
00115                 END;
00116               END;
00117               ELSE IF ANS NE 'O' & ANS NE 'C' THEN DO;
00118                 PUT / 'INCORRECT RESPONSE,' / 'TRY AGAIN WITH '
00119                 'ONE OF THE FOLLOWING RESPONSES:  CHANGE  OK' ;
00120                 GO TO Q2;
00121               END;
00122               END;
00123          PUT / 'IS A COMPLETE TABLED OUTPUT LISTING DESIRED?';
00124          INPUT ANS $;
00125          IF ANS='Y' THEN OPTION2=1; ELSE IF ANS='N' THEN OPTION2=0;
00126 RETURN;
00127 EOF:  FILE TERM;  INFILE SYSTERM MISSOVER;
00128        PUT / 'DO YOU WANT TO ADD ANOTHER CASE?' ;
00129        INPUT ANS $;
00130        IF ANS='Y' THEN DO; END=1; GO TO LABEL; END;
00131 STOP;
00132 DATA REVISE; SET CORRECT;
00133 FILE OLD;
00134 PUT PLANT= TYPE= SERVICE= +3 '/' /
00135      PERIOD= FF= F1= F2= FE2= FE1= +3 '/'  /
00136      MONITOR= VISUAL= REPAIR= PARTS= OCF= CRF=  +3 '/'  /
00137      EI= IFL= TURN= TOTAL= CREDIT= LABOR=  +3  '/'  /
00138      OPTION1= OPTION2= OPTION3= FE= N= +3 '/'  /
00139      SE1= SE2= SE3= SE4= SE5= FFA= FF6= +3 '/'  /
00140      EIA= EIB=  ;
```

Table B-3. PDS Member: SETJCL

```
00001 DATA SETJCL;
00002 INFILE OLD;  INPUT OPTION1=  ;  LENGTH TIME $1;
00003 _ERROR_=0;
00004 IF OPTION1=1 THEN TIME='6'; ELSE TIME='1';
00005 INFILE SYSTERM MISSOVER;
00006 FILE TERM;
00007 LENGTH ACCT $12 USERID $6;
00008 PUT / 'ENTER YOUR 6-CHARACTER USER ID';
00009 INPUT USERID $;
00010 PUT / 'ENTER THE 12-CHARACTER ACCOUNT CODE AUTHORIZED FOR' +1 USERID;
00011 INPUT ACCT $;
00012 PUT / 'ENTER THE INITIATION PRIORITY FOR WHICH YOU WISH TO BE BILLED';
00013 INPUT PRTY ; IF PRTY<=. OR PRTY>5 THEN PRTY=2;
00014 DATARMT=SYSPARM();
00015 DATA=SCAN(DATARMT,1,'/');
00016 RMT=SCAN(DATARMT,2,'/');
00017 FILE JCL; M=-1;
00018 PUT '//' USERID +1 'JOB' +1 '(' ACCT +M ',AAAA),LDARMODEL,CLASS=A,'
00019     'MSGLEVEL=(2,0),'  /
00020     '//' +7 'TIME=' TIME +M ',PRTY=' PRTY /
00021     '/*ROUTE  PRINT'  +2  RMT  /
00022     '//   EXEC   SAS,OPTIONS=''MISSING=.,NONOTES,NOSOURCE'','  /
00023     '//' +7  'REGION=400K'  /
00024     '//SYSOUT  DD  DUMMY' /
00025     '//TERM  DD  DUMMY' /
00026     '//SASLIB  DD  DSN=*.LIBRARY,DISP=(OLD,PASS),VOL=REF=*.LIBRARY' /
00027     '//SYSIN  DD  DSN=CN.EPASDJ.VOCF.LDAR.DATA(MODEL),DISP=SHR' /
00028     '//OLD  DD  DSN=' DATA +M ',DISP=SHR'  /  '//'  ;
00029 STOP;
```

Table B-4. PDS Member: LDAR

```
00001 PROC 0 DEST() DATA() STATUS()
00002 WRITE *** LEAK DETECTION AND REPAIR (LDAR) MODEL  (IN SAS 79.6)
00003 WRITE *** FOR RUNNING AN INTERACTIVE JOB
00004 CONTROL NOMSG
00005 FREE F(WORK FT12F001) ATTRLIST(SPR)
00006 FREE F(SYSOUT FT15F001 OLD RUN TERM SASLIB)
00007 CONTROL MSG PROMPT
00008 ALLOC F(WORK) BLOCK(6394) SPACE(10 10)
00009 ALLOC F(FT15F001) BLOCK(6400) SPACE(10 10)
00010 ATTR SPR RECFM(F B A) LRECL(72) BLKSIZE(5760)
00011 ALLOC F(SYSOUT) DA(*) USING(SPR) DUMMY
00012 ALLOC F(TERM) DA(*) USING(SPR)
00013 ALLOC DA('&DATA.') F(OLD) &STATUS.
00014 ALLOC DA('CN.EPASDJ.VOCF.LDAR.DATA(SETUP)' -
00015           'CN.EPASDJ.VOCF.LDAR.DATA(MODEL)') F(RUN)
00016 ALLOC F(FT12F001) SYSOUT(A) DEST(&DEST.)
00017 ALLOC F(SASLIB) NEW SPACE(5 5) TRACKS DIR(3)
00018 CALL 'SYS2.SAS.LIBRARY(SAS)' -
00019     'SYSIN=RUN NONOTES NOSOURCE SYSPARM=''&DATA./&DEST./&STATUS.'' -
00020      MISSING=.'
00021 WRITE *** OUTPUT SENT TO PRINTER (&DEST.)
```

Table B-5. PDS Member: LDARB

```
00001 PROC 0 DATA() DEST() STATUS()
00002 WRITE *** LEAK DETECTION AND REPAIR (LDAR) MODEL  (IN SAS 79.6)
00003 WRITE *** FOR RUNNING A BATCH JOB
00004 CONTROL NOMSG
00005 FREE F(WORK FT12F001) ATTRLIST(SPR)
00006 FREE F(FT15F001 OLD RUN TERM JCL)
00007 CONTROL MSG PROMPT
00008 ALLOC F(WORK) BLOCK(6394) SPACE(20 100)
00009 ALLOC F(FT15F001) BLOCK(6400) SPACE(10 10)
00010 ATTR SPR RECFM(F B A) LRECL(72) BLKSIZE(5760)
00011 ALLOC F(TERM) DA(*) USING(SPR)
00012 ALLOC DA('&DATA.') F(OLD)  &STATUS.
00013 ALLOC DA('CN.EPASDJ.VOCF.LDAR.JCL.DATA') F(JCL)
00014 ALLOC DA('CN.EPASDJ.VOCF.LDAR.DATA(SETUP)' -
00015           'CN.EPASDJ.VOCF.LDAR.DATA(SETJCL)') F(RUN)
00016 CALL 'SYS2.SAS.LIBRARY(SAS)' -
00017     'SYSIN=RUN NONOTES NOSOURCE SYSPARM=''&DATA./&DEST./&STATUS.'''
00018 SUBMIT 'CN.EPASDJ.VOCF.LDAR.JCL.DATA'
00019 WRITE *** OUTPUT SENT TO PRINTER (&DEST.)
```

APPENDIX C

INPUT AND OUTPUT FOR EXAMPLE RUN

This appendix contains example input and output file listings for the LDAR program. The data given in Tables C-1 and C-2 are the LDAR and JCL input data files, respectively, created by the first example interactive session (submitting a batch job) in Section 4. The file containing the JCL, CN.EPASDJ.VOCF.LDAR.JCL.DATA, is re-created each time a LDAR batch job is submitted. The data set containing the LDAR input data was named by the user when the LDAR program was initiated (CN.EPAiii.VOCF.NEW.DATA). The printouts given in Table C-3 are the hardcopy output files from the first example interactive session. These printouts contain the complete hardcopy output listings as requested by the user.

The data given in Table C-4 are the LDAR input data file created by the second example interactive session (interactive run) in Section 4. This data set was named by the user when the file was initially set up (CN.EPAiii.VOCF.OLD.DATA) by the LDAR program. The printouts given in Table C-5 are the hardcopy output files from the second interactive session. These printouts contain the selected hardcopy output listings as requested by the user.

Table C-1. LDAR Input Data File (From Example Session 1)

```
PLANT=A TYPE=VALVES SERVICE=LIGHT LIQUID    /
PERIOD=3 FF=1.27 F1=62.6 F2=97.7 FE2=14 FE1=10    /
MONITOR=2 VISUAL=0 REPAIR=68 PARTS=0 OCF=40 CRF=16.3    /
EI=0.027 IFL=22 TURN=24 TOTAL=260 CREDIT=215 LABOR=18    /
OPTION1=1 OPTION2=1 OPTION3=1 FE=0 N=0    /
SE1=2 SE2=10 SE3=4 SE4=8 SE5=5 FFA=0.7 FFB=1.9    /
EIA=0.013 EIB=0.054
```

Table C-2. JCL Input Data File (From Example Session 1)

```
//EPASDJ  JOB (VOCFENGRDRAD,AAAA),LDARMODEL,CLASS=A,MSGLEVEL=(2,0),
//        TIME=1,PRTY=2
/*ROUTE  PRINT  RMT15
//   EXEC   SAS,OPTIONS='MISSING=.,NONOTES,NOSOURCE',
//        REGION=400K
//SYSOUT  DD  DUMMY
//TERM  DD  DUMMY
//SASLIB  DD  DSN=*.LIBRARY,DISP=(OLD,PASS),VOL=REF=*.LIBRARY
//SYSIN  DD  DSN=CN.EPASDJ.VOCF.LDAR.DATA(MODEL),DISP=SHR
//OLD  DD  DSN=CN.EPASDJ.VOCF.OLD.DATA,DISP=SHR
//
```

Table C-3. Hardcopy Output File (From Example Session 1)

I N P U T D A T A

PLANT A
(FOR LIGHT LIQUID VALVES)

FOR EXAMINING EMISSION REDUCTIONS DUE TO LDAR*:

MONITORING INTERVAL (MONTHS)	3**	
TURNAROUND FREQUENCY (MONTHS)	24	
EMISSION FACTOR (KG/HR/SOURCE)	0.027	(0.013, 0.054)
LEAK OCCURRENCE RATE (% PER PERIOD)	1.3	(0.7, 1.9)
INITIAL % LEAKING	22.0	(2)
EMISSIONS REDUCTION FOR UNSUCCESSFUL REPAIR (%)	62.6	(10)
EMISSIONS REDUCTION FOR SUCCESSFUL REPAIR (%)	97.7	(4)
EARLY LEAK RECURRENCE (% OF REPAIRS)	14.0	(5)
UNSUCCESSFUL REPAIR RATE (%)	10.0	(8)
UNSUCCESSFUL REPAIR RATE (%) AT TURNAROUND	0.0	

FOR EXAMINING THE COSTS OF LDAR:

TOTAL NUMBER OF SOURCES	260
MONITORING TIME PER SOURCE INSPECTION (MINUTES)	2.0
VISUAL MONITORING TIME PER SOURCE (MINUTES)	0.00
NUMBER OF VISUAL INSPECTIONS PER YEAR	0
REPAIR TIME PER SOURCE (MINUTES)	68
LABOR RATE ($/HOUR)	18
PARTS COST PER SOURCE ($)	0
ADMINISTRATIVE & SUPPORT OVERHEAD COST FACTOR (%)	40.0
CAPITAL RECOVERY FACTOR (%)	16.3
RECOVERY CREDIT FOR EMISSIONS REDUCTION ($/MG)	215

---

* VALUES IN PARENTHESES ARE EITHER THE STANDARD ERROR OF THE ESTIMATE OR THE APPROXIMATE 95% CONFIDENCE BOUNDS ON THE PARAMETER.

** WITH MONTHLY FOLLOW-UPS.

Table C-3 (Continued)

SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR VALVES/ LIGHT LIQUID SERVICE BY YEAR - PLANT A

YEAR	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON
INITIAL	1.0000	0.2200
1	4.4791	0.0908
2	4.0434	0.0708
3	4.1084	0.0600
4	4.0560	0.0679
5	4.1026	0.0596
6	4.0561	0.0678

Table C-3 (Continued)

SUMMARY OF TOTAL FRACTICA OF SOURCES SCREENED AND OPERATED ON FOR VALVES/ LIGHT LIQUID SERVICE BY TURNAROUND - PLANT A

TURNAROUND PERIOD	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON
1	9.5225	0.3816
2	8.1644	0.1279
3	8.1588	0.1274

Table C-3 (Continued)

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND PERCENT REDUCTION IN MASS EMISSIONS FOR VALVES/LIGHT LIQUID SERVICE BY TURNAROUND - PLANT A

TURNAROUND PERIOD	MEAN EMISSION-KG/HR (90% CI)	PERCENT REDUCTION (90% CI)	
		COMPARED TO INITIAL EMISSION	COMPARED TO EMISSION FOR WHICH NO MAINTENANCE WAS DONE DURING PERIOD
1	0.0037 (0.001,0.008)	86.3 (78,95)	88.2 (81,96)
2	0.0035 (0.001,0.007)	86.9 (79,96)	51.9 (35,74)
3	0.0035 (0.001,0.007)	86.9 (79,96)	51.6 (35,73)

Table C-3 (Continued)

FRACTION OF TOTAL SOURCES SCREENED AND OPERATED ON FOR VALVES/LIGHT LIQUID SERVICE
BY MONTH - PLANT A

MONTH	1ST YEAR		2ND YEAR		3RD YEAR		4TH YEAR		5TH YEAR		6TH YEAR	
	FRACTION SCREENED	FRACTION OPERATED ON	FRACTION SCREENED	FRACTION OPERATED ON	FRACTION SCREENED	FRACTION OPERATED ON	FRACTION SCREENED	FRACTION OPERATED ON	FRACTION SCREENED	FRACTION OPERATED ON	FRACTION SCREENED	FRACTION OPERATED ON
INITIAL	1.0000	0.2200	--	--	--	--	--	--	--	--	--	--
1	0.2200	0.0316	0.0112	0.0016	0.0260	0.0037	0.0113	0.0016	0.0229	0.0033	0.0113	0.0016
2	0.2168	0.0049	0.0111	0.0002	0.0256	0.0006	0.0111	0.0003	0.0226	0.0005	0.0111	0.0003
3	0.9964	0.0114	0.5907	0.0125	0.9996	0.0125	0.9938	0.0125	0.9996	0.0125	0.9939	0.0125
4	0.0103	0.0015	0.0112	0.0016	0.0112	0.0016	0.0113	0.0016	0.0113	0.0016	0.0113	0.0016
5	0.0101	0.0002	0.0111	0.0002	0.0111	0.0002	0.0111	0.0002	0.0111	0.0003	0.0111	0.0002
6	0.9950	0.0125	0.9893	0.0124	0.9991	0.0126	0.9924	0.0125	0.9982	0.0126	0.9924	0.0125
7	0.0113	0.0016	0.0112	0.0016	0.0113	0.0016	0.0112	0.0016	0.0113	0.0016	0.0112	0.0016
8	0.0111	0.0003	0.0110	0.0002	0.0111	0.0003	0.0111	0.0002	0.0111	0.0003	0.0111	0.0002
9	0.9936	0.0125	0.9879	0.0124	0.9967	0.0125	0.9909	0.0125	0.9967	0.0125	0.9910	0.0125
10	0.0113	0.0016	0.0112	0.0016	0.0113	0.0016	0.0112	0.0016	0.0113	0.0016	0.0112	0.0016
11	0.0111	0.0002	0.0110	0.0002	0.0111	0.0003	0.0111	0.0002	0.0111	0.0003	0.0111	0.0002
12	0.9922	0.0125	0.9864	0.0260	0.9952	0.0125	0.9895	0.0229	0.9953	0.0125	0.9896	0.0229

Table C-3 (Continued)

ESTIMATED EMISSION FACTORS (KG/HR) AND PERCENT REDUCTION
IN MASS EMISSIONS FOR VALVES/LIGHT LIQUID SERVICE BY PERIOD - PLANT A

PERIOD (3 MONTHS)	MEAN EMISSION-KG/HR (90% CI)	PERCENT REDUCTION (90% CI)	
		COMPARED TO INITIAL EMISSION	COMPARED TO EMISSION FOR WHICH NO MAINTENANCE WAS DONE DURING PERIOD
1	0.0038 (0.001,0.008)	86.1 (78,95)	86.3 (79,95)
2	0.0035 (0.001,0.007)	87.0 (79,96)	87.7 (80,96)
3	0.0036 (0.001,0.007)	86.7 (79,96)	88.0 (81,96)
4	0.0036 (0.001,0.007)	86.5 (79,96)	88.2 (81,96)
5	0.0037 (0.001,0.008)	86.3 (78,95)	88.4 (82,96)
6	0.0037 (0.001,0.008)	86.1 (78,95)	88.7 (82,96)
7	0.0038 (0.001,0.008)	85.9 (78,95)	88.9 (83,96)
8	0.0039 (0.001,0.008)	85.7 (78,95)	89.0 (83,96)
9	0.0034 (0.001,0.007)	87.5 (80,96)	9.4 (3,30)
10	0.0034 (0.001,0.007)	87.4 (79,96)	33.5 (18,62)
11	0.0035 (0.001,0.007)	87.2 (79,96)	47.0 (28,73)
12	0.0035 (0.001,0.007)	87.0 (79,96)	55.6 (36,79)
13	0.0036 (0.001,0.007)	86.8 (79,96)	61.7 (42,82)
14	0.0036 (0.001,0.008)	86.6 (79,96)	66.2 (48,85)
15	0.0037 (0.001,0.008)	86.4 (78,96)	69.6 (52,87)
16	0.0037 (0.001,0.008)	86.2 (78,95)	72.4 (55,88)
17	0.0034 (0.001,0.007)	87.6 (80,96)	8.4 (2,25)
18	0.0034 (0.001,0.007)	87.4 (79,96)	33.0 (17,61)
19	0.0035 (0.001,0.007)	87.2 (79,96)	46.6 (28,73)
20	0.0035 (0.001,0.007)	87.0 (79,96)	55.4 (36,79)
21	0.0036 (0.001,0.007)	86.8 (79,96)	61.5 (42,82)
22	0.0036 (0.001,0.008)	86.6 (79,96)	66.1 (47,85)
23	0.0037 (0.001,0.008)	86.4 (78,96)	69.5 (52,87)
24	0.0037 (0.001,0.008)	86.2 (78,95)	72.3 (55,88)

Table C-3 (Continued)

FRACTIONAL DISTRIBUTION OF SOURCES FOR VALVES/LIGHT LIQUID SERVICE
BY PERIOD - PLANT A

PERIOD (3 MONTHS)	FRACTION OF LEAKERS* DUE TO OCCURRENCE AT END OF PERIOD(1)	FRACTION OF UNREPAIRED SOURCES		FRACTION OF SOURCES EXPERIENCING EARLY FAILURE		FRACTION OF SOURCES OPERATING PROPERLY	
		BEGINNING(2) OF PERIOD	END OF PERIOD	BEGINNING OF PERIOD	END OF PERIOD	BEGINNING OF PERIOD	END OF PERIOD
INITIAL	0.220	---	0.000	---	0.0000	---	0.780
1	0.011	0.000	0.004	0.0308	0.0006	0.969	0.985
2	0.012	0.005	0.005	0.0014	0.0000	0.994	0.983
3	0.012	0.006	0.006	0.0016	0.0000	0.992	0.981
4	0.012	0.008	0.008	0.0016	0.0000	0.991	0.980
5	0.012	0.009	0.009	0.0016	0.0000	0.989	0.978
6	0.012	0.011	0.011	0.0016	0.0000	0.988	0.977
7	0.012	0.012	0.012	0.0016	0.0000	0.986	0.975
8	0.012	0.013	0.014	0.0016	0.0000	0.985	0.974
9	0.012	0.000	0.000	0.0036	0.0001	0.996	0.987
10	0.013	0.002	0.002	0.0016	0.0000	0.997	0.986
11	0.013	0.003	0.003	0.0016	0.0000	0.995	0.984
12	0.012	0.005	0.005	0.0016	0.0000	0.994	0.983
13	0.012	0.006	0.006	0.0016	0.0000	0.992	0.981
14	0.012	0.007	0.008	0.0016	0.0000	0.991	0.980
15	0.012	0.009	0.009	0.0016	0.0000	0.990	0.978
16	0.012	0.010	0.010	0.0016	0.0000	0.988	0.977
17	0.012	0.000	0.000	0.0032	0.0001	0.997	0.987
18	0.013	0.002	0.002	0.0016	0.0000	0.997	0.986
19	0.013	0.003	0.003	0.0016	0.0000	0.995	0.984
20	0.012	0.005	0.005	0.0016	0.0000	0.994	0.983
21	0.012	0.006	0.006	0.0016	0.0000	0.992	0.981
22	0.012	0.007	0.008	0.0016	0.0000	0.991	0.980
23	0.012	0.009	0.009	0.0016	0.0000	0.990	0.979
24	0.012	0.010	0.010	0.0016	0.0000	0.988	0.977

* LEAKERS REFERS TO THOSE SOURCES SCREENING GREATER THAN OR EQUAL TO 10,000 PPMV.
(1) JUST BEFORE PERIODIC MAINTENANCE IS PERFORMED.
(2) IMMEDIATELY FOLLOWING PERIODIC MAINTENANCE.

Table C-3 (Continued)

PLANT A SUMMARY:

INITIAL LEAK REPAIR COSTS

SOURCE TYPE	INITIAL LEAK FREQ	NUMBER OF SOURCES	NUMBER OF INITIAL LEAKS	INITIAL LEAK REPAIR COSTS				ANNUALIZED CHARGES
				PARTS	LABOR	ADMIN & SUPPORT	TOTAL	
VALVES								
LIGHT LIQUID	0.220	260	57	$ 0	$ 1,170	$ 467	$ 1,630	$ 266

Table C-3 (Continued)

MONITORING AND LEAK REPAIR COSTS - PLANT A
(QUARTERLY LDAR FOR LIGHT LIQUID VALVES)

YEAR	MONITORING LABOR COSTS	ONGOING REPAIR COSTS		ADMIN AND SUPPORT COSTS	ANNUALIZED CHARGE FOR INITIAL LEAK REPAIR	GROSS COST
		LABOR	PARTS			
1	$ 855	$ 482	$ 0	$ 535	$ 266	$ 2,140
2	631	375	0	402	266	1,670
3	641	318	0	384	266	1,610
4	633	360	0	397	266	1,660
5	640	316	0	382	266	1,600
6	633	360	0	397	266	1,660
TOTAL	$ 4,030	$ 2,210	$ 0	$ 2,500	$ 1,600	$ 10,300
ANNUAL AVG	$ 637	$ 339	$ 0	$ 390	$ 266	$ 1,630

Table C-3 (Continued)

PLANT A SUMMARY:

AVERAGE ANNUAL MONITORING AND LEAK REPAIR COSTS
(QUARTERLY LDAR)

SOURCE TYPE	MONITORING LABOR COSTS	ONGOING REPAIR COSTS		ADMIN AND SUPPORT COSTS	ANNUALIZED CHARGE FOR INITIAL LEAK REPAIR	GROSS COST
		LABOR	PARTS			
VALVES						
LIGHT LIQUID	$ 637	$ 339	$ 0	$ 390	$ 266	$ 1,630
PLANT TOTAL	$ 637	$ 339	$ 0	$ 390	$ 266	$ 1,630

Table C-3 (Continued)

COST EFFECTIVENESS - PLANT A
(QUARTERLY LDAR FOR LIGHT LIQUID VALVES)

YEAR	EMISSION REDUCTION (MG/YR)	RECOVERY CREDIT	NET COSTS	GROSS COST EFFECTIVENESS (PER MG)	NET COST EFFECTIVENESS (PER MG)
1	53.2	$ 11,400	$ -9,310	$ 40	$ -175
2	52.9	11,400	-9,700	32	-183
3	53.7	11,500	-9,930	30	-185
4	53.2	11,400	-9,780	31	-184
5	53.7	11,500	-9,940	30	-185
6	53.2	11,400	-9,780	31	-184
TOTAL	320	$ 68,800	$ -58,400	$ 32	$ -183
ANNUAL AVG	53.4	$ 11,500	$ -9,850	$ 31	$ -184

Table C-3 (Continued)

PLANT A SUMMARY:

AVERAGE ANNUAL COST EFFECTIVENESS
(QUARTERLY LDAR)

SOURCE TYPE	EMISSION REDUCTION (MG/YR)	RECOVERY CREDIT	NET COSTS	GROSS COST EFFECTIVENESS (PER MG)	NET COST EFFECTIVENESS (PER MG)
VALVES					
LIGHT LIQUID	53.4	$ 11,500	$ -9,850	$ 31	$ -184
PLANT TOTAL	53.4	$ 11,500	$ -9,850	$ 31	$ -184

Table C-4. LDAR Input Data File (From Example Session 2)

```
PLANT=A TYPE=VALVES SERVICE=GAS    /
PERIOD=1 FF=1.27 F1=62.6 F2=97.7 FE2=14 FE1=10    /
MONITOR=2 VISUAL=0 REPAIR=68 PARTS=0 OCF=40 CRF=16.3    /
EI=0.027 IFL=22 TURN=24 TOTAL=260 CREDIT=215 LABOR=18    /
OPTION1=0 OPTION2=0 OPTION3=0 FE=0 N=0    /
SE1=. SE2=. SE3=. SE4=. SE5=. FFA=. FFB=.    /
EIA=. EIB=.
PLANT=A TYPE=PUMP SEALS SERVICE=LIGHT LIQUID    /
PERIOD=1 FF=1.3 F1=65 F2=97.7 FE2=14 FE1=10    /
MONITOR=10 VISUAL=0.5 REPAIR=960 PARTS=113 OCF=40 CRF=16.3    /
EI=0.027 IFL=12 TURN=24 TOTAL=200 CREDIT=215 LABOR=18    /
OPTION1=0 OPTION2=0 OPTION3=0 FE=0 N=52    /
SE1=. SE2=. SE3=. SE4=. SE5=. FFA=. FFB=.    /
EIA=. EIB=.
PLANT=A TYPE=PUMP SEALS SERVICE=HEAVY LIQUID    /
PERIOD=1 FF=1.27 F1=62.6 F2=97.7 FE2=14 FE1=10    /
MONITOR=10 VISUAL=0.5 REPAIR=960 PARTS=113 OCF=40 CRF=16.3    /
EI=0.055 IFL=10 TURN=24 TOTAL=410 CREDIT=215 LABOR=18    /
OPTION1=0 OPTION2=0 OPTION3=0 FE=0 N=52    /
SE1=. SE2=. SE3=. SE4=. SE5=. FFA=. FFB=.    /
EIA=. EIB=.
```

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Table C-5. Hardcopy Output File (From Example Session 2)

I N P U T D A T A

PLANT A
(FOR HEAVY LIQUID PUMP SEALS)

FOR EXAMINING EMISSION REDUCTIONS DUE TO LDAR:

MONITORING INTERVAL (MONTHS)	1
TURNAROUND FREQUENCY (MONTHS)	24
EMISSION FACTOR (KG/HR/SOURCE)	0.055
LEAK OCCURRENCE RATE (% PER PERIOD)	1.3
INITIAL % LEAKING	10.0
EMISSIONS REDUCTION FOR UNSUCCESSFUL REPAIR (%)	62.6
EMISSIONS REDUCTION FOR SUCCESSFUL REPAIR (%)	97.7
EARLY LEAK RECURRENCE (% OF REPAIRS)	14.0
UNSUCCESSFUL REPAIR RATE (%)	10.0
UNSUCCESSFUL REPAIR RATE (%) AT TURNAROUND	0.0

FOR EXAMINING THE COSTS OF LDAR:

TOTAL NUMBER OF SOURCES	410
MONITORING TIME PER SOURCE INSPECTION (MINUTES)	10.0
VISUAL MONITORING TIME PER SOURCE (MINUTES)	0.50
NUMBER OF VISUAL INSPECTIONS PER YEAR	52
REPAIR TIME PER SOURCE (MINUTES)	960
LABOR RATE ($/HOUR)	18
PARTS COST PER SOURCE ($)	113
ADMINISTRATIVE & SUPPORT OVERHEAD COST FACTOR (%)	40.0
CAPITAL RECOVERY FACTOR (%)	16.3
RECOVERY CREDIT FOR EMISSIONS REDUCTION ($/MG)	215

Table C-5 (Continued)

INPUT DATA

PLANT A
(FOR LIGHT LIQUID PUMP SEALS)

FOR EXAMINING EMISSION REDUCTIONS DUE TO LDAR:

MONITORING INTERVAL (MONTHS)	1
TURNAROUND FREQUENCY (MONTHS)	24
EMISSION FACTOR (KG/HR/SOURCE)	0.027
LEAK OCCURRENCE RATE (% PER PERIOD)	1.3
INITIAL % LEAKING	12.0
EMISSIONS REDUCTION FOR UNSUCCESSFUL REPAIR (%)	65.0
EMISSIONS REDUCTION FOR SUCCESSFUL REPAIR (%)	97.7
EARLY LEAK RECURRENCE (% OF REPAIRS)	14.0
UNSUCCESSFUL REPAIR RATE (%)	10.0
UNSUCCESSFUL REPAIR RATE (%) AT TURNAROUND	0.0

FOR EXAMINING THE COSTS OF LDAR:

TOTAL NUMBER OF SOURCES	200
MONITORING TIME PER SOURCE INSPECTION (MINUTES)	10.0
VISUAL MONITORING TIME PER SOURCE (MINUTES)	0.50
NUMBER OF VISUAL INSPECTIONS PER YEAR	52
REPAIR TIME PER SOURCE (MINUTES)	960
LABOR RATE ($/HOUR)	18
PARTS COST PER SOURCE ($)	113
ADMINISTRATIVE & SUPPORT OVERHEAD COST FACTOR (%)	40.0
CAPITAL RECOVERY FACTOR (%)	16.3
RECOVERY CREDIT FOR EMISSIONS REDUCTION ($/MG)	215

Table C-5 (Continued)

INPUT DATA

PLANT A
(FOR GAS VALVES)

FOR EXAMINING EMISSION REDUCTIONS DUE TO LDAR:

MONITORING INTERVAL (MONTHS)	1
TURNAROUND FREQUENCY (MONTHS)	24
EMISSION FACTOR (KG/HR/SOURCE)	0.027
LEAK OCCURRENCE RATE (% PER PERIOD)	1.3
INITIAL % LEAKING	22.0
EMISSIONS REDUCTION FOR UNSUCCESSFUL REPAIR (%)	62.6
EMISSIONS REDUCTION FOR SUCCESSFUL REPAIR (%)	97.7
EARLY LEAK RECURRENCE (% OF REPAIRS)	14.0
UNSUCCESSFUL REPAIR RATE (%)	10.0
UNSUCCESSFUL REPAIR RATE (%) AT TURNAROUND	0.0

FOR EXAMINING THE COSTS OF LDAR:

TOTAL NUMBER OF SOURCES	260
MONITORING TIME PER SOURCE INSPECTION (MINUTES)	2.0
VISUAL MONITORING TIME PER SOURCE (MINUTES)	0.00
NUMBER OF VISUAL INSPECTIONS PER YEAR	0
REPAIR TIME PER SOURCE (MINUTES)	68
LABOR RATE ($/HOUR)	18
PARTS COST PER SOURCE ($)	0
ADMINISTRATIVE & SUPPORT OVERHEAD COST FACTOR (%)	40.0
CAPITAL RECOVERY FACTOR (%)	16.3
RECOVERY CREDIT FOR EMISSIONS REDUCTION ($/MG)	215

Table C-5 (Continued)

SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR PUMP SEALS/ HEAVY LIQUID SERVICE BY TURNAROUND - PLANT A

TURNAROUND PERIOD	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON
1	24.5729	0.4899
2	23.5914	0.3812
3	23.5916	0.3810

Table C-5 (Continued)

SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR PUMP SEALS/
LIGHT LIQUID SERVICE BY TURNAROUND - PLANT A

TURNAROUND PERIOD	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON
1	24.5567	0.5219
2	23.5817	0.3900
3	23.5821	0.3899

Table C-5 (Continued)

SUMMARY OF TOTAL FRACTION OF SOURCES SCREENED AND OPERATED ON FOR VALVES/GAS SERVICE BY TURNAROUND - PLANT A

TURNAROUND PERIOD	TOTAL FRACTION OF SOURCES SCREENED	TOTAL FRACTION OF SOURCES OPERATED ON
1	24.5303	0.6300
2	23.5907	0.3815
3	23.5916	0.3810

Table C-5 (Continued)

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND PERCENT REDUCTION IN MASS EMISSIONS FOR PUMP SEALS/HEAVY LIQUID SERVICE BY TURNAROUND - PLANT A

TURNAROUND PERIOD	MEAN EMISSION-KG/HR	PERCENT REDUCTION	
		COMPARED TO INITIAL EMISSION	COMPARED TO EMISSION FOR WHICH NO MAINTENANCE WAS DONE DURING PERIOD
1	0.0165	70.0	84.6
2	0.0163	70.4	72.7
3	0.0163	70.4	72.6

Table C-5 (Continued)

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND PERCENT REDUCTION
IN MASS EMISSIONS FOR PUMP SEALS/LIGHT LIQUID SERVICE BY TURNAROUND - PLANT A

TURNAROUND PERIOD	MEAN EMISSION-KG/HR	PERCENT REDUCTION	
		COMPARED TO INITIAL EMISSION	COMPARED TO EMISSION FOR WHICH NO MAINTENANCE WAS DONE DURING PERIOD
1	0.0069	74.3	85.9
2	0.0069	74.6	73.2
3	0.0069	74.6	73.2

Table C-5 (Continued)

SUMMARY OF ESTIMATED EMISSION FACTORS (KG/HR) AND PERCENT REDUCTION IN MASS EMISSIONS FOR VALVES/GAS SERVICE BY TURNAROUND - PLANT A

TURNAROUND PERIOD	MEAN EMISSION-KG/HR	PERCENT REDUCTION	
		COMPARED TO INITIAL EMISSION	COMPARED TO EMISSION FOR WHICH NO MAINTENANCE WAS DONE DURING PERIOD
1	0.0042	84.4	89.3
2	0.0041	85.0	72.7
3	0.0041	85.0	72.7

Table C-5 (Continued)

PLANT A SUMMARY:

INITIAL LEAK REPAIR COSTS

SOURCE TYPE	INITIAL LEAK FREQ	NUMBER OF SOURCES	NUMBER OF INITIAL LEAKS	INITIAL LEAK REPAIR COSTS				ANNUALIZED CHARGES
				PARTS	LABOR	ADMIN & SUPPORT	TOTAL	
PUMP SEALS								
HEAVY LIQUID	0.100	410	41	$ 4,630	$ 11,800	$ 4,720	$ 21,200	$ 3,450
LIGHT LIQUID	0.120	200	24	2,710	6,910	2,760	12,400	2,020
VALVES								
GAS	0.220	260	57	0	1,170	467	1,630	266

Table C-5 (Continued)

PLANT A SUMMARY:

AVERAGE ANNUAL MONITORING AND LEAK REPAIR COSTS
(MONTHLY LDAR)

SOURCE TYPE	MONITORING LABOR COSTS	CAGOING REPAIR COSTS		ADMIN AND SUPPORT COSTS	ANNUALIZED CHARGE FOR INITIAL LEAK REPAIR	GROSS COST
		LABOR	PARTS			
PUMP SEALS						
HEAVY LIQUID	$ 17,700	$ 22,500	$ 8,830	$ 16,100	$ 3,450	$ 68,600
LIGHT LIQUID	8,650	11,200	4,410	7,950	2,020	34,200
VALVES						
GAS	1,840	1,010	0	1,140	266	4,260
PLANT TOTAL	$ 28,200	$ 34,700	$ 13,200	$ 25,200	$ 5,740	$ 107,000

Table C-5 (Continued)

PLANT A SUMMARY:

AVERAGE ANNUAL COST EFFECTIVENESS
(MONTHLY LOAR)

SOURCE TYPE	EMISSION REDUCTION (MG/YR)	RECOVERY CREDIT	NET COSTS	GROSS COST EFFECTIVENESS (PER MG)	NET COST EFFECTIVENESS (PER MG)
PUMP SEALS					
HEAVY LIQUID	139	$ 29,900	$ 38,700	$ 493	$ 278
LIGHT LIQUID	35.3	7,590	26,700	970	755
VALVES					
GAS	52.2	11,200	-6,970	82	-133
PLANT TOTAL	227	$ 48,700	$ 58,400	$ 473	$ 258